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ON THE TENDENCY OF SPECIES TO FORM VARIETIES; AND ON THE PERPETUATION OF VARIETIES AND SPECIES BY NATURAL MEANS OF SELECTION.*

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(Read July 1, 1858.)

LONDON, June 30th, 1858.

My Dear Sir:—The accompanying papers, which we have the honour of communicating to the Linnean Society, and which all relate to the same subject, viz., the Laws which affect the Production of Varieties, Races, and Species, contain the results of the investigations of two indefatigable naturalists, Mr. Charles Darwin and Mr. Alfred Wallace.

* From Vol. III. (1858) of the 'Journal' of the Linnean Society. The original announcement of the principle of the origin of species by natural selection made by Darwin and Wallace before the Linnean Society will be of great interest to readers of this journal. It is perhaps the most important event in the history of science, and the circumstances give to it a dramatic character. Sir Charles Lyell and Sir Joseph Hooker explain in their letter of transmission how it came to pass that the manuscripts were presented. In this connection, however, the following extract of a letter from Darwin to Lyell (June 25, 1858) may be reproduced:

There is nothing in Wallace's sketch which is not written out much fuller in my sketch, copied out in 1844, and read by Hooker some dozen years ago. About a year ago I sent a short sketch, of which I have a copy, of my views (owing to correspondence on several points) to Asa Gray, so that I could most truly say and prove that I take nothing from Wallace. I should be extremely glad now to publish a sketch of my general views in about a dozen pages or so; but I cannot persuade myself that I can do so honourably. Wallace says nothing about publication, and I enclose his letter. But as I had not intended to publish any sketch, can I do so honourably, because Wallace has sent me an outline of his doctrine? I would far rather burn my whole book, than that he

These gentlemen having, independently and unknown to one another, conceived the same very ingenious theory to account for the appearance and perpetuation of varieties and of specific forms on our planet, may both fairly claim the merit of being original thinkers in this important line of inquiry; but neither of them having published his views, though Mr. Darwin has for many years past been repeatedly urged by us to do so, and both authors having now unreservedly placed their papers in our hands, we think it would best promote the interests of science that a selection from them should be laid before the Linnean Society.

Taken in the order of their dates, they consist of:

1. Extracts from a MS. work on Species,* by Mr. Darwin, which was sketched in 1839, and copied in 1844, when the copy was read by Dr. Hooker, and its contents afterwards communicated to Sir Charles Lyell. The first Part is devoted to 'The Variation of Organic Beings under Domestication and in their Natural State'; and the second chapter of that Part, from which we propose to read to the Society the extracts referred to, is headed, 'On the Variation of Organic Beings in a state of Nature; on the Natural Means of Selection; on the Comparison of Domestic Races and true Species.'

2. An abstract of a private letter addressed to Professor Asa Gray, of Boston, U. S., in October, 1857, by Mr. Darwin, in which he repeats his views, and which shows that these remained unaltered from 1839 to 1857.

3. An Essay by Mr. Wallace, entitled 'On the Tendency of Varieties to depart indefinitely from the Original Type.' This was written at Ternate in February, 1858, for the perusal of his friend and correspondent Mr. Darwin, and sent to him with the expressed wish that it should be forwarded to Sir Charles Lyell, if Mr. Darwin thought it sufficiently novel and interesting. So highly did Mr. Darwin appreciate the value of the views therein set forth, that he proposed, in a letter to Sir Charles Lyell, to obtain Mr. Wallace's consent to allow the Essay to be published as soon as possible. Of this step we highly approved, provided Mr. Darwin did not withhold from the public, as

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or any other man should think that I had behaved in a paltry spirit. Do you not think his having sent me this sketch ties my hands? * * * If I could honourably publish, I would state that I was now induced to publish a sketch (and I should be very glad to be permitted to say, to follow your advice long ago given) from Wallace having sent me an outline of my general conclusions. We differ only, [in] that I was led to my views from what artificial selection has done for domestic animals. I would send Wallace a copy of my letter to Asa Gray, to show him that I had not stolen his doctrine. But I cannot tell whether to publish now would not be base and paltry. This was my first impression, and I should have certainly have acted on it had it not been for your letter.

* This MS. work was never intended for publication, and therefore was not written with care.—C. D., 1858.

he was strongly inclined to do (in favor of Mr. Wallace), the memoir which he had himself written on the same subject, and which, as before stated, one of us had perused in 1844, and the contents of which we had both of us been privy to for many years. On representing this to Mr. Darwin, he gave us permission to make what use we thought proper of his memoir, &c.; and in adopting our present course, of presenting it to the Linnean Society, we have explained to him that we are not solely considering the relative claims to priority of himself and his friend, but the interests of science generally; for we feel it to be desirable that views founded on a wide deduction from facts, and matured by years of reflection, should constitute at once a goal from which others may start, and that, while the scientific world is waiting for the appearance of Mr. Darwin's complete work, some of the leading results of his labours, as well as those of his able correspondent, should together be laid before the public.

We have honour to be yours very obediently,

CHARLES LYELL.
JOS. D. HOOKER.

J. J. BENNETT, Esq.,
Secretary of the Linnean Society.

1. *Extract from an unpublished Work on Species, by* C. DARWIN, Esq., *consisting of a portion of a Chapter entitled, 'On the Variation of Organic Beings in a state of Nature; on the Natural Means of Selection; on the Comparison of Domestic Races and true Species.'*

De Candolle, in an eloquent passage, has declared that all nature is at war, one organism with another, or with external nature. Seeing the contented face of nature, this may at first well be doubted; but reflection will inevitably prove it to be true. The war, however, is not constant, but recurrent in a slight degree at short periods, and more severely at occasional more distant periods; and hence its effects are easily overlooked. It is the doctrine of Malthus applied in most cases with tenfold force. As in every climate there are seasons, for each of its inhabitants, of greater and less abundance, so all annually breed; and the moral restraint which in some small degree checks the increase of mankind is entirely lost. Even slow-breeding mankind has doubled in twenty-five years; and if he could increase his food with greater ease, he would double in less time. But for animals without artificial means, the amount of food for each species must, *on an average,* be constant, whereas the increase of all organisms tends to be geometrical, and in a vast majority of cases at an enormous ratio. Suppose in a certain spot there are eight pairs of birds, and that *only* four pairs of them annually (including double hatches) rear only four young, and that these go on rearing their young at the same rate, then at the end

of seven years (a short life, excluding violent deaths, for any bird) there will be 2048 birds, instead of the original sixteen. As this increase is quite impossible, we must conclude either that birds do not rear nearly half their young, or that the average life of a bird is, from accident, not nearly seven years. Both checks probably concur. The same kind of calculation applied to all plants and animals affords results more or less striking, but in very few instances more striking than in man.

Many practical illustrations of this rapid tendency to increase are on record, among which, during peculiar seasons, are the extraordinary numbers of certain animals; for instance, during the years 1826 to 1828, in La Plata, when from drought some millions of cattle perished, the whole country actually *swarmed* with mice. Now I think it cannot be doubted that during the breeding-season all the mice (with the exception of a few males or females in excess) ordinarily pair, and therefore that this astounding increase during three years must be attributed to a greater number than usual surviving the first year, and then breeding, and so on till the third year, when their numbers were brought down to their usual limits on the return of wet weather. Where man has introduced plants and animals into a new and favourable country, there are many accounts in how surprisingly few years the whole country has become stocked with them. This increase would necessarily stop as soon as the country was fully stocked; and yet we have every reason to believe, from what is known of wild animals, that *all* would pair in the spring. In the majority of cases it is most difficult to imagine where the checks fall—though generally, no doubt, on the seeds, eggs, and young; but when we remember how impossible, even in mankind (so much better known than any other animal), it is to infer from repeated casual observations what the average duration of life is, or to discover the different percentage of deaths to births in different countries, we ought to feel no surprise at our being unable to discover where the check falls in any animal or plant. It should always be remembered, that in most cases the checks are recurrent yearly in a small, regular degree, and in an extreme degree during unusually cold, hot, dry, or wet years, according to the constitution of the being in question. Lighten any check in the least degree, and the geometrical powers of increase in every organism will almost instantly increase the average number of the favoured species. Nature may be compared to a surface on which rest ten thousand sharp wedges touching each other and driven inwards by incessant blows. Fully to realize these views much reflection is requisite. Malthus on man should be studied; and all such cases as those of the mice in La Plata, of the cattle and horses when first turned out in South America, of the birds by our calculation, etc., should be well considered. Reflect on the enormous multiplying

power *inherent and annually in action* in all animals; reflect on the countless seeds scattered by a hundred ingenious contrivances, year after year, over the whole face of the land; and yet we have every reason to suppose that the average percentage of each of the inhabitants of a country usually remains constant. Finally, let it be borne in mind that this average number of individuals (the external conditions remaining the same) in each country is kept up by recurrent struggles against other species or against external nature (as on the borders of the Arctic regions, where the cold checks life), and that ordinarily each individual of every species holds its place, either by its own struggle and capacity of acquiring nourishment in some period of its life, from the egg upwards; or by the struggle of its parents (in short-lived organisms, when the main check occurs at longer intervals) with other individuals of the *same* or *different* species.

But let the external conditions of a country alter. If in a small degree, the relative proportions of the inhabitants will in most cases simply be slightly changed; but let the number of inhabitants be small, as on an island, and free access to it from other countries be circumscribed, and let the change of conditions continue progressing (forming new stations), in such a case the original inhabitants must cease to be as perfectly adapted to the changed conditions as they were originally. It has been shown in a former part of this work, that such changes of external conditions would, from their acting on the reproductive system, probably cause the organization of those beings which were most affected to become, as under domestication, plastic. Now, can it be doubted, from the struggle each individual has to obtain subsistence, that any minute variation in structure, habits, or instincts, adapting that individual better to the new conditions, would tell upon its vigour and health? In the struggle it would have a better *chance* of surviving; and those of its offspring which inherited the variation, be it ever so slight, would also have a better *chance*. Yearly more are bred than can survive; the smallest grain in the balance, in the long run, must tell on which death shall fall, and which shall survive. Let this work of selection on the one hand, and death on the other, go on for a thousand generations, who will pretend to affirm that it would produce no effect, when we remember what, in a few years, Bakewell effected in cattle, and Western in sheep, by this identical principle of selection?

To give an imaginary example from changes in progress on an island:—let the organization of a canine animal which preyed chiefly on rabbits, but sometimes on hares, become slightly plastic; let these same changes cause the number of rabbits very slowly to decrease, and the number of hares to increase; the effect of this would be that the fox or dog would be driven to try to catch more hares; his organization, however, being slightly plastic, those individuals with the lightest forms,

longest limbs, and best eyesight, let the difference be ever so small, would be slightly favoured, and would tend to live longer, and to survive during that time of the year when food was scarcest; they would also rear more young, which would tend to inherit these slight peculiarities. The less fleet ones would be rigidly destroyed. I can see no more reason to doubt that these causes in a thousand generations would produce a marked effect, and adapt the form of the fox or dog to the catching of hares instead of rabbits, than that greyhounds can be improved by selection and careful breeding. So would it be with plants under similar circumstances. If the number of individuals of a species with plumed seeds could be increased by greater powers of dissemination within its own area (that is, if the check to increase fell chiefly on the seeds), those seeds which were provided with ever so little more down, would in the long run be most disseminated; hence a greater number of seeds thus formed would germinate, and would tend to produce plants inheriting the slightly better-adapted down.*

Besides this natural means of selection, by which those individuals are preserved, whether in their egg, or larval, or mature state, which are best adapted to the place they fill in nature, there is a second agency at work in most unisexual animals, tending to produce the same effect, namely, the struggle of the males for the females. These struggles are generally decided by the law of battle, but in the case of birds, apparently, by the charms of their song, by their beauty or their power of courtship, as in the dancing rock-thrush of Guiana. The most vigourous and healthy males, implying perfect adaptation, must generally gain the victory in their contests. This kind of selection, however, is less rigorous than the other; it does not require the death of the less successful, but gives to them fewer descendants. The struggle falls, moreover, at a time of the year when food is generally abundant, and perhaps the effect chiefly produced would be the modification of the secondary sexual characters, which are not related to the power of obtaining food, or to defence from enemies, but to fighting with or rivalling other males. The result of this struggle amongst the males may be compared in some respects to that produced by those agriculturists who pay less attention to the careful selection of all their young animals, and more to the occasional use of a choice mate.

2. *Abstract of a Letter from* C. DARWIN, *Esq., to Professor* ASA GRAY, *Boston, U. S., dated Down, September 5th,* 1857.

1. It is wonderful what the principle of selection by man, that is the picking out of individuals with any desired quality, and breeding from them, and again picking out, can do. Even breeders have been astounded at their own results. They can act on differences inappre-

* I can see no more difficulty in this, than in the planter improving his varieties of the cotton plant.—C. D., 1858.

ciable to an uneducated eye. Selection has been *methodically* followed in *Europe* for only the last half century; but it was occasionally, and even in some degree methodically, followed in the most ancient times. There must have been also a kind of unconscious selection from a remote period, namely in the preservation of the individual animals (without any thought of their offspring) most useful to each race of man in his particular circumstances. The 'roguing,' as nurserymen call the destroying of varieties which depart from their type, is a kind of selection. I am convinced that intentional and occasional selection has been the main agent in the production of our domestic races; but however this may be, its great power of modification has been indisputably shown in later times. Selection acts only by the accumulation of slight or greater variations, caused by external conditions, or by the mere fact that in generation the child is not absolutely similar to its parent. Man, by this power of accumulating variations, adapts living beings to his wants—may be said to make the wool of one sheep good for carpets, of another for cloth, etc.

2. Now suppose there were a being who did not judge by mere external appearances, but who could study the whole internal organization, who was never capricious, and should go on selecting for one object during millions of generations; who will say what he might not effect? In nature we have some *slight* variations occasionally in all parts; and I think it can be shown that changed conditions of existence is the main cause of the child not exactly resembling its parents; and in nature geology shows us what changes have taken place and are taking place. We have almost unlimited time; no one but a practical geologist can fully appreciate this. Think of the Glacial period, during the whole of which the same species at least of shells have existed; there must have been during this period millions on millions of generations.

3. I think it can be shown that there is such an unerring power at work in *Natural Selection* (the title of my book), which selects exclusively for the good of each organic being. The elder De Candolle, W. Herbert, and Lyell have written excellently on the struggle for life; but even they have not written strongly enough. Reflect that every being (even the elephant) breeds at such a rate, that in a few years, or at most a few centuries, the surface of the earth would not hold the progeny of one pair. I have found it hard constantly to bear in mind that the increase of every single species is checked during some part of its life, or during some shortly recurrent generation. Only a few of those annually born can live to propagate their kind. What a trifling difference must often determine which shall survive, and which perish!

4. Now take the case of a country undergoing some change. This will tend to cause some of its inhabitants to vary slightly—not but that I believe most beings vary at all times enough for selection to act on

them. Some of its inhabitants will be exterminated; and the remainder will be exposed to the mutual action of a different set of inhabitants, which I believe to be far more important to the life of each being than mere climate. Considering the infinitely various methods which living beings follow to obtain food by struggling with other organisms, to escape danger at various times of life, to have their eggs or seeds disseminated, etc., etc., I cannot doubt that during millions of generations individuals of a species will be occasionally born with some slight variation, profitable to some part of their economy. Such individuals will have a better chance of surviving, and of propagating their new and slightly different structure; and the modification may be slowly increased by the accumulative action of natural selection to any profitable extent. The variety thus formed will either coexist with, or, more commonly, will exterminate its parent form. An organic being, like the woodpecker or misseltoe, may thus come to be adapted to a score of contingencies—natural selection accumulating those slight variations in all parts of its structure, which are in any way useful to it during any part of its life.

5. Multiform difficulties will occur to every one, with respect to this theory. Many can, I think, be satisfactorily answered. *Natura non facit saltum* answers some of the most obvious. The slowness of the change, and only a few individuals undergoing change at one time, answers others. The extreme imperfection of our geological records answers others.

6. Another principle, which may be called the principle of divergence, plays, I believe, an important part in the origin of species. The same spot will support more life if occupied by very diverse forms. We see this in the many generic forms in a square yard of turf, and in the plants or insects on any little uniform islet, belonging almost invariably to as many genera and families as species. We can understand the meaning of this fact amongst the higher animals, whose habits we understand. We know that it has been experimentally shown that a plot of land will yield a greater weight if sown with several species and genera of grasses, than if sown with only two or three species. Now, every organic being, by propagating so rapidly, may be said to be striving its utmost to increase in numbers. So it will be with the offspring of any species after it has become diversified into varieties, or sub-species, or true species. And it follows, I think, from the foregoing facts, that the varying offspring of each species will try (only few will succeed) to seize on as many and as diverse places in the economy of nature as possible. Each new variety or species, when formed, will generally take the place of, and thus exterminate its less well-fitted parent. This I believe to be the origin of the classification and affinities of organic beings at all times; for organic beings always

seem to branch and sub-branch like the limbs of a tree from a common trunk, the flourishing and diverging twigs destroying the less vigorous —the dead and lost branches rudely representing extinct genera and families.

This sketch is *most* imperfect; but in so short a space I cannot make it better. Your imagination must fill up very wide blanks.

C. DARWIN.

3. *On the Tendency of Varieties to depart indefinitely from the Original Type. By* ALFRED RUSSEL WALLACE.

One of the strongest arguments which have been adduced to prove the original and permanent distinctness of species is, that *varieties* produced in a state of domesticity are more or less unstable, and often have a tendency, if left to themselves, to return to the normal form of the parent species; and this instability is considered to be a distinctive peculiarity of all varieties, even of those occurring among wild animals in a state of nature, and to constitute a provision for preserving unchanged the originally created distinct species.

In the absence or scarcity of facts and observations as to *varieties* occurring among wild animals, this argument has had great weight with naturalists, and has led to a very general and somewhat prejudiced belief in the stability of species. Equally general, however, is the belief in what are called 'permanent or true varieties,'—races of animals which continually propagate their like, but which differ so slightly (although constantly) from some other race, that the one is considered to be a *variety* of the other. Which is the *variety* and which the original *species,* there is generally no means of determining, except in those rare cases in which the one race has been known to produce an offspring unlike itself and resembling the other. This, however, would seem quite incompatible with the 'permanent invariability of species,' but the difficulty is overcome by assuming that such varieties have strict limits, and can never again vary further from the original type, although they may return to it, which, from the analogy of the domesticated animals, is considered to be highly probable, if not certainly proved.

It will be observed that this argument rests entirely on the assumption, that *varieties* occurring in a state of nature are in all respects analogous to or even identical with those of domestic animals, and are governed by the same laws as regards their permanence or further variation. But it is the object of the present paper to show that this assumption is altogether false, that there is a general principle in nature which will cause many *varieties* to survive the parent species, and to give rise to successive variations departing further and further from the original type, and which also produces, in domesticated animals, the tendency of varieties to return to the parent form.

The life of wild animals is a struggle for existence. The full exertion of all their faculties and all their energies is required to preserve their own existence and provide for that of their infant offspring. The possibility of procuring food during the least favourable seasons, and of escaping the attacks of their most dangerous enemies, are the primary conditions which determine the existence both of individuals and of entire species. These conditions will also determine the population of a species; and by a careful consideration of all the circumstances we may be enabled to comprehend, and in some degree to explain, what at first sight appears so inexplicable—the excessive abundance of some species, while others closely allied to them are very rare.

The general proportion that must obtain between certain groups of animals is readily seen. Large animals cannot be so abundant as small ones; the carnivora must be less numerous than the herbivora; eagles and lions can never be so plentiful as pigeons and antelopes; the wild asses of the Tartarian deserts cannot equal in numbers the horses of the more luxuriant prairies and pampas of America. The greater or less fecundity of an animal is often considered to be one of the chief causes of its abundance or scarcity; but a consideration of the facts will show us that it really has little or nothing to do with the matter. Even the least prolific of animals would increase rapidly if unchecked, whereas it is evident that the animal population of the globe must be stationary, or perhaps, through the influence of man, decreasing. Fluctuations there may be; but permanent increase, except in restricted localities, is almost impossible. For example, our own observation must convince us that birds do not go on increasing every year in a geometrical ratio, as they would do, were there not some powerful check to their natural increase. Very few birds produce less than two young ones each year, while many have six, eight, or ten; four will certainly be below the average; and if we suppose that each pair produce young only four times in their life, that will also be below the average, supposing them not to die either by violence or want of food. Yet at this ratio how tremendous would be the increase in a few years from a single pair! A simple calculation will show that in fifteen years each pair of birds would have increased to nearly ten millions! whereas we have no reason to believe that the number of the birds of any country increases at all in fifteen or in one hundred and fifty years. With such powers of increase the population must have reached its limits, and have become stationary, in a very few years after the origin of each species. It is evident, therefore, that each year an immense number of birds must perish—as many in fact as are born; and as on the lowest calculation the progeny are each year twice as numerous as their parents, it follows that, whatever be the average number of individuals existing in any given country, *twice that number*

must perish annually,—a striking result, but one which seems at least highly probable, and is perhaps under rather than over the truth. It would therefore appear that, as far as the continuance of the species and the keeping up the average number of individuals are concerned, large broods are superfluous. On the average all above *one* become food for hawks and kites, wild cats and weasels, or perish of cold and hunger as winter comes on. This is strikingly proved by the case of particular species; for we find that their abundance in individuals bears no relation whatever to their fertility in producing offspring. Perhaps the most remarkable instance of an immense bird population is that of the passenger pigeon of the United States, which lays only one, or at most two eggs, and is said to rear generally but one young one. Why is this bird so extraordinarily abundant, while others producing two or three times as many young are much less plentiful? The explanation is not difficult. The food most congenial to this species, and on which it thrives best, is abundantly distributed over a very extensive region, offering such differences of soil and climate, that in one part or another of the area the supply never fails. The bird is capable of a very rapid and long-continued flight, so that it can pass without fatigue over the whole of the district it inhabits, and as soon as the supply of food begins to fail in one place, is able to discover a fresh feeding-ground. This example strikingly shows us that the procuring a constant supply of wholesome food is almost the sole condition requisite for ensuring the rapid increase of a given species, since neither the limited fecundity, nor the unrestrained attacks of birds of prey and of man are here sufficient to check it. In no other birds are these peculiar circumstances so strikingly combined. Either their food is more liable to failure, or they have not sufficient power of wing to search for it over an extensive area, or during some season of the year it becomes very scarce, and less wholesome substitutes have to be found; and thus, though more fertile in offspring, they can never increase beyond the supply of food in the least favourable seasons. Many birds can only exist by migrating, when their food becomes scarce, to regions possessing a milder, or at least a different climate, though, as these migrating birds are seldom excessively abundant, it is evident that the countries they visit are still deficient in a constant and abundant supply of wholesome food. Those whose organization does not permit them to migrate when their food becomes periodically scarce, can never attain a large population. This is probably the reason why woodpeckers are scarce with us, while in the tropics they are among the most abundant of solitary birds. Thus the house sparrow is more abundant than the red-breast, because its food is more constant and plentiful,—seeds of grasses being preserved during the winter, and our farm-yards and stubble-fields furnishing an almost inexhaustible sup-

ply. Why, as a general rule, are aquatic, and especially sea birds, very numerous in individuals? Not because they are more prolific than others, generally the contrary; but because their food never fails, the sea-shores and river-banks daily swarming with a fresh supply of small mollusca and crustacea. Exactly the same laws will apply to mammals. Wild cats are prolific and have few enemies; why then are they never as abundant as rabbits? The only intelligible answer is, that their supply of food is more precarious. It appears evident, therefore, that so long as a country remains physically unchanged, the numbers of its animal population cannot materially increase. If one species does so, some others requiring the same kind of food must diminish in proportion. The numbers that die annually must be immense; and as the individual existence of each animal depends upon itself, those that die must be the weakest—the very young, the aged, and the diseased,—while those that prolong their existence can only be the most perfect in health and vigor—those who are best able to obtain food regularly, and avoid their numerous enemies. It is, as we commenced by remarking, 'a struggle for existence,' in which the weakest and least perfectly organized must always succumb.

Now it is clear that what takes place among the individuals of a species must also occur among the several allied species of a group,—viz., that those which are best adapted to obtain a regular supply of food, and to defend themselves against the attacks of their enemies and the vicissitudes of the seasons, must necessarily obtain and preserve a superiority in population; while those species which from some defect of power or organization are the least capable of counteracting the vicissitudes of food supply, etc., must diminish in numbers, and, in extreme cases, become altogether extinct. Between these extremes the species will present various degrees of capacity for ensuring the means of preserving life; and it is thus we account for the abundance or rarity of species. Our ignorance will generally prevent us from accurately tracing the effects to their causes; but could we become perfectly acquainted with the organization and habits of the various species of animals, and could we measure the capacity of each for performing the different acts necessary to its safety and existence under all the varying circumstances by which it is surrounded, we might be able even to calculate the proportionate abundance of individuals which is the necessary result.

If now we have succeeded in establishing these two points—1st, *that the animal population of a country is generally stationary, being kept down by a periodical deficiency of food, and other checks;* and, 2d, *that the comparative abundance or scarcity of the individuals of the several species is entirely due to their organization and resulting habits, which, rendering it more difficult to procure a regular supply of*

food and to provide for their personal safety in some cases than in others, can only be balanced by a difference in the population which have to exist in a given area—we shall be in a condition to proceed to the consideration of *varieties*, to which the preceding remarks have a direct and very important application.

Most or perhaps all the variations from the typical form of a species must have some definite effect, however slight, on the habits or capacities of the individuals. Even a change of colour might, by rendering them more or less distinguishable, affect their safety; a greater or less development of hair might modify their habits. More important changes, such as an increase in power or dimensions of the limbs or any of the external organs, would more or less affect their mode of procuring food, or the range of country which they inhabit. It is also evident that most changes would affect, either favourably or adversely, the powers of prolonging existence. An antelope with shorter or weaker legs must necessarily suffer more from the attacks of the feline carnivora; the passenger pigeon with less powerful wings would sooner or later be affected in its powers of procuring a regular supply of food; and in both cases the result must necessarily be a diminution of the population of the modified species. If, on the other hand, any species should produce a variety having slightly increased powers of preserving existence, that variety must inevitably in time acquire a superiority in numbers. These results must follow as surely as old age, intemperance, or scarcity of food produce an increased mortality. In both cases there may be many individual exceptions; but on the average the rule will invariably be found to hold good. All varieties will therefore fall into two classes—those which under the same conditions would never reach the population of the parent species, and those which would in time obtain and keep a numerical superiority. Now, let some alteration of physical conditions occur in the district—a long period of drought, a destruction of vegetation by locusts, the irruption of some new carnivorous animal seeking 'pastures new'—any change in fact tending to render existence more difficult to the species in question, and tasking its utmost powers to avoid complete extermination; it is evident that, of all the individuals composing the species, those forming the least numerous and most feebly organized variety would suffer first, and, were the pressure severe, must soon become extinct. The same causes continuing in action, the parent species would next suffer, would gradually diminish in numbers, and with a recurrence of similar unfavourable conditions might also become extinct. The superior variety would then alone remain, and on a return to favourable circumstances would rapidly increase in numbers and occupy the place of the extinct species and variety.

The *variety* would now have replaced the *species,* of which it would be a more perfectly developed and more highly organized form. It would be in all respects better adapted to secure its safety, and to prolong its individual existence and that of the race. Such a variety *could not* return to the original form; for that form is an inferior one, and could never compete with it for existence. Granted, therefore, a 'tendency' to reproduce the original type of the species, still the variety must ever remain preponderant in numbers, and under adverse physical conditions *again alone survive.* But this new, improved, and populous race might itself, in course of time, give rise to new varieties, exhibiting several diverging modifications of form, any of which, tending to increase the facilities for preserving existence, must, by the same general law, in their turn become predominant. Here, then, we have *progression and continued divergence* deduced from the general laws which regulate the existence of animals in a state of nature, and from the undisputed fact that varieties do frequently occur. It is not, however, contended that this result would be invariable; a change of physical conditions in the district might at times materially modify it, rendering the race which had been the most capable of supporting existence under the former conditions now the least so, and even causing the extinction of the newer, and, for a time, superior race, while the old or parent species and its first inferior varieties continued to flourish. Variations in unimportant parts might also occur, having no perceptible effect on the life-preserving powers; and the varieties so furnished might run a course parallel with the parent species, either giving rise to further variations or returning to the former type. All we argue for is, that certain varieties have a tendency to maintain their existence longer than the original species, and this tendency must make itself felt; for though the doctrine of chances or averages can never be trusted to on a limited scale, yet, if applied to high numbers, the results come nearer to what theory demands, and, as we approach to an infinity of examples, become strictly accurate. Now the scale on which nature works is so vast—the numbers of individuals and periods of time with which she deals approach so near to infinity, that any cause, however slight, and however liable to be veiled and counteracted by accidental circumstances, must in the end produce its full legitimate results.

Let us now turn to domesticated animals, and inquire how varieties produced among them are affected by the principles here enunciated. The essential difference in the condition of wild and domestic animals is this,—that among the former, their well-being and very existence depends upon the full exercise and healthy condition of all their senses and physical powers, whereas, among the latter, these are only partially exercised, and in some cases are absolutely unused. A wild animal has to search, and often to labour, for every mouthful of food—to ex-

ercise sight, hearing, and smell in seeking it, and in avoiding dangers, in procuring shelter from the inclemency of the seasons, and in providing for the subsistence and safety of its offspring. There is no muscle of its body that is not called into daily and hourly activity; there is no sense or faculty that is not strengthened by continual exercise. The domestic animal, on the other hand, has food provided for it, is sheltered and often confined, to guard it against the vicissitudes of the seasons, is carefully secured from the attacks of its natural enemies, and seldom even rears its young without human assistance. Half of its senses and faculties are quite useless; and the other half are but occasionally called into feeble exercise, while even its muscular system is only irregularly called into action.

Now when a variety of such an animal occurs, having increased power or capacity in any organ or sense, such increase is totally useless, is never called into action, and may even exist without the animal ever becoming aware of it. In the wild animal, on the contrary, all its faculties and powers being brought into full action for the necessities of existence, any increase becomes immediately available, is strengthened by exercise, and must even slightly modify the food, the habits, and the whole economy of the race. It creates as it were a new animal, one of superior powers, and which will necessarily increase in numbers and outlive those inferior to it.

Again, in the domesticated animal all variations have an equal chance of continuance; and those which would decidedly render a wild animal unable to compete with its fellows and continue its existence are no disadvantage whatever in a state of domesticity. Our quickly fattening pigs, short-legged sheep, pouter pigeons, and poodle dogs could never have come into existence in a state of nature, because the very first step towards such inferior forms would have led to the rapid extinction of the race; still less could they now exist in competition with their wild allies. The great speed but slight endurance of the race horse, the unwieldy strength of the ploughman's team, would both be useless in a state of nature. If turned wild on the pampus, such animals would probably soon become extinct, or under favourable circumstances might each lose those extreme qualities which would never be called into action, and in a few generations would revert to a common type, which must be that in which the various powers and faculties are so proportioned to each other as to be best adapted to procure food and secure safety,—that in which by the full exercise of every part of his organization the animal can alone continue to live. Domestic varieties, when turned wild, *must* return to something near the type of the original wild stock, *or become altogether extinct.*

We see, then, that no inferences as to varieties in a state of nature can be deduced from the observation of those occurring among domestic

animals. The two are so much opposed to each other in every circumstance of their existence, that what applies to the one is almost sure not to apply to the other. Domestic animals are abnormal, irregular, artificial; they are subject to varieties which never occur and never can occur in a state of nature: their very existence depends altogether on human care; so far are many of them removed from that just proportion of faculties, that true balance of organization, by means of which alone an animal left to its own resources can preserve its existence and continue its race.

The hypothesis of Lamarck—that progressive changes in species have been produced by the attempts of animals to increase the development of their own organs, and thus modify their structure and habits—has been repeatedly and easily refuted by all writers on the subject of varieties and species, and it seems to have been considered that when this was done the whole question has been finally settled; but the view here developed renders such an hypothesis quite unnecessary, by showing that similar results must be produced by the action of principles constantly at work in nature. The powerful retractile talons of the falcon- and the cat-tribes have not been produced or increased by the volition of those animals; but among the different varieties which occurred in the earlier and less highly organized form of these groups, *those always survived longest which had the greatest facilities for seizing their prey.* Neither did the giraffe acquire its long neck by desiring to reach the foliage of the more lofty shrubs, and constantly stretching its neck for the purpose, but because any varieties which occurred among its anti-types with a longer neck than usual *at once secured a fresh range of pasture over the same ground as their shorter-necked companions, and on the first scarcity of food were thereby enabled to outlive them.* Even the peculiar colours of many animals, especially insects, so closely resembling the soil or the leaves or the trunks on which they habitually reside, are explained on the same principle; for though in the course of ages varieties of many tints may have occurred, *yet those races having colours best adapted to concealment from their enemies would inevitably survive the longest.* We have also here an acting cause to account for that balance so often observed in nature,—a deficiency in one set of organs always being compensated by an increased development of some others—powerful wings accompanying weak feet, or great velocity making up for the absence of defensive weapons; for it has been shown that all varieties in which an unbalanced deficiency occurred could not long continue their existence. The action of this principle is exactly like that of the centrifugal governor of the steam engine, which checks and corrects any irregularities almost before they become evident; and in like manner no unbalanced deficiency in the animal kingdom can ever reach

any conspicuous magnitude, because it would make itself felt at the very first step, by rendering existence difficult and extinction almost sure soon to follow. An origin such as is here advocated will also agree with the peculiar character of the modifications of form and structure which obtain in organized beings—the many lines of divergence from a central type, the increasing efficiency and power of a particular organ through a succession of allied species, and the remarkable persistence of unimportant parts such as colour, texture of plumage and hair, form of horns or crests, through a series of species differing considerably in more essential characters. It also furnishes us with a reason for that 'more specialized structure' which Professor Owen states to be a characteristic of recent compared with extinct forms, and which would evidently be the result of the progressive modification of any organ applied to a special purpose in the animal economy.

We believe we have now shown that there is a tendency in nature to the continued progression of certain classes of *varieties* further and further from the original type—a progression to which there appears no reason to assign any definite limits—and that the same principle which produces this result in a state of nature will also explain why domestic varieties have a tendency to revert to the original type. This progression, by minute steps, in various directions, but always checked and balanced by the necessary conditions, subject to which alone existence can be preserved, may, it is believed, be followed out so as to agree with all the phenomena presented by organized beings, their extinction and succession in past ages, and all the extraordinary modifications of form, instinct, and habits which they exhibit.

TERNATE, February, 1858.

THE STORY OF THE CAHOW.

THE MYSTERIOUS EXTINCT BIRD OF THE BERMUDAS.

By PROFESSOR A. E. VERRILL,
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WHEN the Bermudas were first visited by Europeans, about three hundred years ago, they had never been occupied by man. In this respect they differed from most islands of a similar size and blessed with a genial climate.

The study of the character of their original fauna and flora and of the changes subsequently wrought by man is, therefore, of peculiar interest. Fortunately there were several educated and intelligent men in the two parties who were wrecked upon the islands (1593 and 1609) to whom we owe the first intelligent descriptions of the islands and their products. These writers and others who settled there in 1612 to 1616, all agree in respect to the wonderful abundance of certain sea-birds, whose eggs and flesh contributed very largely to their food supply. Indeed, it is probable that without this source of food those shipwrecked parties would have died of starvation. Even later, in 1615, during a famine that occurred among the settlers, the birds furnished for a time a large part of their food. One of these abundant and useful birds they called the 'egg-bird,' because its spotted eggs were laid in vast numbers, openly, in May, on some of the smaller sandy islands 'reserved for their use.' This was undoubtedly a tern, probably the common tern, or the roseate tern, both of which were still breeding in small numbers on Gurnet Rock in 1850.

Perhaps both these species of terns were included under the general name of 'egg-birds,' for two or more species often breed together and have similar eggs. The noddy tern may also have been one of them, for it is mentioned under this name by one of the early writers.

But the terns were so continually and persistently robbed and killed that they were soon driven from their breeding grounds or exterminated. They are now known only as migrants. As breeding birds they have long been extinct at the Bermudas, the last records of their breeding being about fifty years ago. Among the formerly abundant birds there is one, however, of far greater interest; originally called the 'cahow' or 'cohowe,' with various other spellings, from its singular note. This bird is unknown to science and is, so far as known, totally extinct.

At the time of the early settlements (1612 to 1615) it bred in great numbers on some of the smaller islands and was easily captured at night. It laid a single, large, white egg, described as like a hen's egg in size, color and flavor. The nest was, according to all early writers, except one, a burrow in the sand like a coney's, and *not* in crevices of the rocks, like that of the shearwaters, with which many writers have tried to identify it. Governor Nathaniel Butler, in his 'Historye of the Bermudaes,' writing about 1619, states that its eggs and young were found in crevices of the ledges, but he probably did not have the advantage of personal experience.

The time of laying its eggs is another very remarkable thing, in which it differed from all other birds of northern latitudes. The early contemporary writers all agree that it laid its eggs 'in December and January' or 'in the coldest and darkest months of the year.' The shearwaters, even in the West Indies, lay their eggs in spring (March

CASTLE ISLAND, LOOKING SOUTH; *a*, ANCIENT RUINED FORT OR CITADEL; *b*, BARRACKS AND BATTERY; *c*, ANCIENT WALL, BROKEN DOWN AT *c'* BY THE HURRICANE OF SEPT. 12, 1899; *d*, MAIN ISLAND OF BERMUDA.

and April) and their eggs are so musky that they are not edible; certainly no one would compare them to a hen's egg. Their flesh has, also, so strong a flavor of bad fish-oil and musk that no one would eat it, unless on the verge of starvation.

The bird itself was variously described as of the size of a pigeon, green plover or sea mew; its bill was hooked and strong, and it could bite viciously; its back was 'russet brown' and there were russet and white quillfeathers in its wings; its belly was white. It was strictly nocturnal in its habits, and could be called within reach of the hand by making loud vocal notes. Its flesh was described as of excellent flavor, and for that reason it was captured at night in large numbers, while its eggs were constantly gathered for food. It arrived in October and remained until the first of June.

There is no known living bird that agrees with it in these several characters. Most certainly it could not have been a shearwater, nor any

member of the petrel family, all of which have such a disagreeable flavor that neither their flesh nor eggs are edible. It seems to me far more probable that it was allied to the auks (*Alcidæ*), many of which burrow in the ground and lay white, edible eggs. The northern auks also have edible flesh and often a strong hooked bill.

But no existing species breeds so far south, nor do they breed in winter. The cahow may have spent the summer in the southern hemisphere, but possibly it was an arctic bird that produced a southern brood in winter. Or it may have been a localized pelagic species, coming to the land only for breeding purposes.

The following graphic account of the bird and its habits was written by Mr. W. Strachy, one of the party of 150 persons who were wrecked with Sir George Somers in the 'Sea Venture,' July, 1609:

"A kinde of webbe-footed Fowle there is, of the bignesse of an English greene Plover, or Sea-Meawe, which all the Summer we saw not, and in the darkest nights of November and December (for in the night they onely feed) they would come forth, but not flye farre from home, and hovering in the ayre, and over the Sea, made a strange hollow and harsh howling. They call it of the cry which it maketh, a Cohow. Their colour is inclining to Russet, with white bellies, as are likewise the long feathers of their wings, Russet and White, these gather themselves together and breed in those Ilands which are high, and so farre alone into the Sea, that the Wilde Hogges cannot swimme over them, and there in the ground they have their Burrowes, like Conyes in a Warren, and so brought in the loose Mould, though not so deepe; which Birds with a light bough in a darke night (as in our Lowbelling) wee caught, I have beene at the taking of three hundred in an houre, and wee might have laden our Boates. Our men found a prettie way to take them, which was by standing on the Rockes or Sands by the Sea-side, and hollowing, laughing, and making the strangest outcry that possibly they could; with the noyse whereof the Birds would come flocking to that place, and settle upon the very armes and head of him that so cryed, and still creepe neerer and neerer, answering the noyse themselves; by which our men would weigh them with their hand, and which weighed heaviest they took for the best and let the others alone, and so our men would take twentie dozen in two houres of the chiefest of them; and they were a good and well relished Fowle, fat and full as a Partridge. In January wee had great store of their Egges, which are as great as an Hennes Egge, and so fashioned and white shelled and have no difference in yolke nor white from an Hennes Egge. There are thousands of these Birds, and two or three Ilands full of their Burrowes, whether at any time (in two houres warning) wee could send our Cockboat, and bring home as many as would serve the whole Company: which Birds for their blindnesse (for they see weakly in the day) and for their cry and whooting, wee called the Sea Owle; they will bite cruelly with their crooked Bills."

The following description is taken from 'The Narrative' (1610), by Silvanus Jourdain, who was also one of Somers's party:

"Another Sea fowle there is that lyeth in little holes in the ground, like unto Coney holes, and are in great numbers exceedingly good meate, very fat and sweet (those we had in the winter and their eggs are white, and of that

bignesse, that they are not to be knowne from these egges. The other birds egges are speckled and of a different colour."

In a letter written from the 'Summer Islands,' Dec., 1614, by the Rev. Lewis Hughes, the following account of the cahow occurs:

"Here is also plenty of sea foules, at one time of the yeare, as about the middle of October, Birds which we call cahouze and Pimlicoes come in. The Cahouze continue til the beginning of June in great abundance, they are bigger bodied than a Pigeon & of a very firm & good flesh. They are taken with ease if one do but sit downe in a darke night, and make a noise, there will more come to him then he shall be able to kill: some have told me that they have taken twelve or fourteen dozen in an hower. When the Cahouze time is out, other birds called noddies and sandie birds come in, and continue till the latter end of August."

This is the only account that gives the time of its arrival and departure.

The following extract is from Governor Butler's 'Historye,' written about 1619:

"For the cahowe (for so soundes his voice), it is a night bird, and all the daye long lies hidd in holes of the rocks, whence both themselves and their young are in great numbers extracted with ease, and prove (especially the young) so pleaseinge in a dish, as ashamed I am to tell, how many dosen of them have been devoured by some one of our northern stomacks, even at one only meale."

This is the only original statement that I find, among the early writings, that it lives in holes of rocks. It is possible, however, that it lived in all available holes, either in those made in the soil by the abundant land crabs or those found among rocks. It may not have made its own burrows, when other holes were available. Captain John Smith's account was compiled from those given above. He did not visit Bermuda.

There are several references to this bird in the local laws of Bermuda. Even so early as 1616 a law was passed restricting the taking of the bird and its eggs, because of the rapid decrease in its numbers.

It is thus referred to in Governor Butler's 'Historye.'

"In the same moneth he held his second generall Assize at St. George's, as irregularly as the first, wherin not any matter of note was handled, only a proclamation (or rather article, as it was then tearmed) was published (but overlate) against the spoyle and havock of the cahowes, and other birds, which already wer almost all of them killed and scared awaye very improvidently by fire, diggeinge, stoneinge, and all kinds of murtheringes."

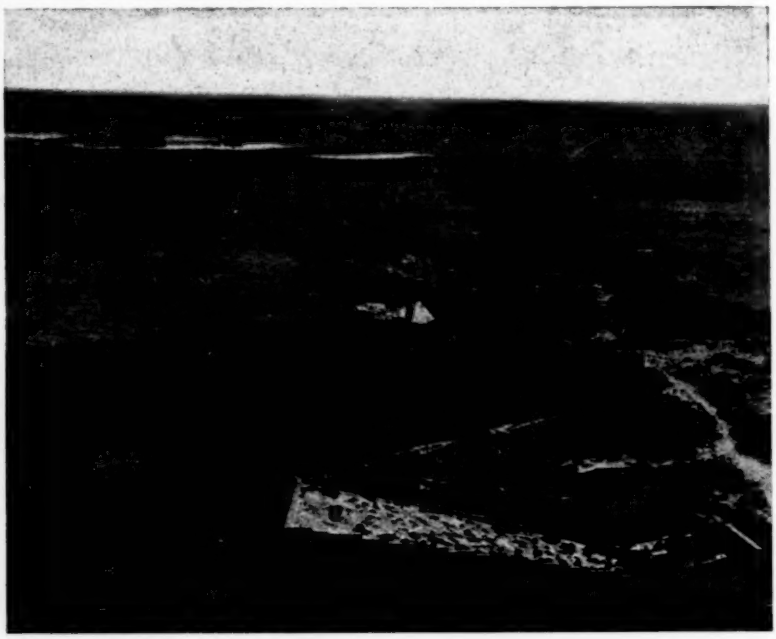
Among the laws enacted by the Bermuda Company, 1621-22, was the following:

"The Governour, and other officers, shall take care for the preservation of the breed of Birds, by reserving to them those Ilands whereunto they resort."

This doubtless refers to the egg-birds as well as to the cahow. It seems to have been almost or quite forgotten for over 200 years. In

1849, Mr. J. L. Hurdis visited Gurnet Rock or 'Gurnet Head Rock,' a small, precipitous, and nearly inaccessible outlying island, situated off Castle Harbor, and found there the nests of a shearwater *in the crevices of the rocks*. He concluded that he had found and identified the long-lost cahow.

His identification has been accepted by Capt. S. G. Reid and other later writers on the ornithology of the Bermudas, apparently without any adequate consideration of the facts stated by the early writers from personal observation. It has been assumed by nearly all recent writers, though without any real evidence, that Gurnet (Head)



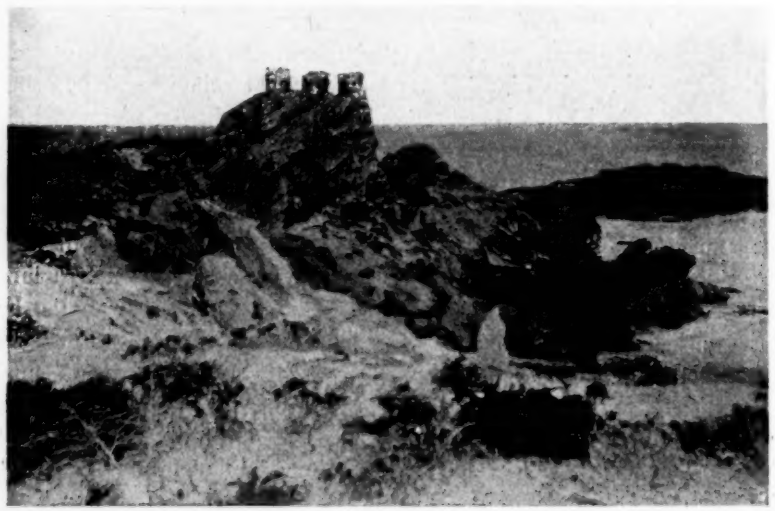
ANCIENT RUINED FORT *a* ON GURNET'S HEAD OF CASTLE ISLAND; *b*, WATER CISTERN, STILL HOLDING WATER; *c*, CATCHMENT SLOPE, BUILT OF SLABS OF LIMESTONE; *d*, GURNET HEAD ROCK; *e*, ENTRANCE TO CASTLE HARBOR.

Rock was the particular place, or at least one of the places, where the cahow bred in old times. Perhaps this may be due to the name, but it was called 'Gurnet Head Rock,' because it lies off 'Gurnet Head' on Castle Island. The latter name was in use in 1619. Some of the early writers say that it bred on some of the smaller uninhabited islands, inaccessible to the wild hogs, without designating any particular one (see Strachy's narrative). Governor Butler and the Rev. Lewis Hughes say that a boat could go to its breeding places and get a load of the bird and its eggs in a short time (see Strachy's account, above). This was apparently done only in the night. Therefore the islands visited

must have been near at hand and easily accessible, with available and safe landings, even in winter, when the eggs were sought. Gurnet Rock does not fulfill any of these conditions. It is several miles from St. George's, then the chief settlement and capital; it stands isolated outside all the other islands, so that it is exposed to the full force of the sea on all sides and in December and January the sea is always boisterous in these waters; it has no place where a boat can safely land, unless in nearly calm weather and by daylight; its sides are nearly perpendicular, exceeding rough, high cliffs, which can hardly be scaled without risk of loss of life or limbs, unless by means of ropes and ladders. Moreover the top is of very small area and almost destitute of soil. So that there is no possible chance for a bird like the cahow to burrow there. The writer, with two companions, visited this island about the first of May of this year, on a day when the sea was not very rough, and the tide was low. We found it impossible to land except by stepping out upon a narrow, slippery and treacherous reef of rotten rock and corallines, covered with sea-weeds, exposed only at low tide, and standing a little away from the shore, with deep water between. The sea was breaking over this reef, and it was difficult to wade ashore except at one place, on account of the depth of water. With the aid of a long pole I climbed partly up the side of the rock, at the only available place, and though I did not reach the summit, I could, from my highest position, see that there is no soil on the top, but only a few seaside shrubs and herbaceous plants, growing from crevices of the rock. This was sufficient to convince me that the cahow never bred on this rock, and, if it had, the early settlers would never have gone there in the winter and at night to get the eggs or birds.

It is far more probable that one of its breeding places was on Goat Island, which is a larger, uninhabited island about half a mile inside of Gurnet Rock, and with a beach of shell-sand on the inner side, where boats can safely land. Moreover on this island, in early times, there was a deep deposit of sand and soil, which was subsequently used as a burial place for soldiers who died in the old fortifications on this and the adjacent Castle Island and Southampton Island. Indeed we found two ancient human skeletons partly exposed in this bank of sand, where it had been recently undermined by the sea. Evidently a large amount of this sandy deposit, which contains fossil land snails, has been washed away since the time when the old 'Charles Fort' was built upon this island, about 1615. This old ruined fort was of small size and apparently has been abandoned since about 1630. It has the same size and form shown on Norwood's chart, published in 1626. Norwood mentions, in 1663, that it had then 'fallen into decay.' Probably the cahow may have bred also on Castle Island, which is a larger island a short distance inside Goat Island, and on Southampton Island,

GURNET'S HEAD OF CASTLE ISLAND, SHOWING PROFILE AT *a*; *b*, SOUTHAMPTON ISLAND AND RUINS OF THE FORT, BUILT BOUT 1620; *c*, ENTRANCE TO CASTLE HARBOR.



GOAT ISLAND (FORMERLY CHARLES' ISLAND), WITH RUINS OF CHARLES' FORT, BUILT ABOUT 1615.

a little farther west. But these and other adjacent islands, including Cooper's Island, were fortified between 1612 and 1620, and it is probable that their occupation, at that time and later, was one of the causes of the rapid extermination of the cahow and egg-birds. We endeavored to secure some bones of the cahow by digging in the rubbish heaps about the old forts on Castle Island, but though we found numerous bones of fishes, hogs, etc., and a few of birds, none appear to belong to the cahow. But probably the deposits that we excavated were of later date, for the Castle Island forts were again garrisoned during the war of 1812. We found old silver and brass military buttons, gun flints and the cores of flint nodules, from which they had been chipped, with many other old relics, but nothing to indicate the first period of occupation, from 1614 to 1625, when alone the cahow might have formed a part of the rations.

In the 'Plain and True Relation' by the Rev. Lewis Hughes, 1621, there is a graphic account of the famine of 1615, from which the following extract is taken:

"The first night that I lay in the Iland, which you call Coopers Iland (whither the lazie starving crewe were sent, and with them some honest industrious persons, though then much out of heart, and now living, and well, thanks unto God) when I saw in every Cabbin Pots and kettles full of birds boyling, and some on spits rosting, and the silly wilde birds comming so tame into my cabbin and goe so familiarly betweene my feet, and round about the cabbin, and into the fire, with a strange lamentable noyse, as though they did bemoan us, and bid us take, kill, roast, and eate them: I was much amazed, and at length said within myselfe, surely the tameness of these wilde birds, and their offring of themselves to be taken, is a manifest token of the goodnesse of God even of his love, his care, his mercy and power working together, to save this people from starving. Mr. Moore then Governour, fearing that their overeating themselves would be their destruction, did remove them from thence to Port Royoll, where they found but little or no want; for, birds they had there also, brought to them, every weeke, from the Ilands adjoyning, whither some were sent of purpose to bird for them."

This account of the habits of the cahow would not, in the least, apply to the shearwater. It is probable, however, that the latter is identical with the nocturnal bird called 'Pimlico' by the early settlers.

The following extract from the 'Historye' by Governor Nathaniel Butler, written about 1619, relates to the famine of 1615, and shows some of the causes of the very rapid extermination of the birds:

"Whilst this Pinnace was on her way for England, scarcetie and famine every day more and more prevayleinge upon the sickly colony, caused the governour to look well about him; in the beginning of the newe yeare, therefore (1615), 150 persons, of the most ancient, sick, and weake, wer sent into Coopers Iland, ther to be relieved by the comeinge in of the sea-birds, especially the Cahowes, wher, by this half hunger-starved company, they are found in infinite numbers, and with all so tame and amazed they are, that upon the least howeteinge or noyce, they would fall downe, and light upon their shoulders

as they went, and leggs as they satt, suffering themselves to be caught faster than they could be killed." "Wittnesse the generall carriage and behaviour of this company, who being thus arrived and gott up to a libertie and choice of eateing as much as they would, how monstrous was it to see, how greedily everything was swallowed downe; how incredible to speake, how many dozen of thoes poore silly creatures, that even offered themselves to the slaughter, wer tumbled downe into their bottomlesse mawes: wherupon (as the sore effect of so ranck a cause, the birds with all being exceedeingly fatt) then sodenly followed a generall surfettinge, much sicknesse, and many of their deathes."

The chances of finding bones of the cahow would probably be better on Cooper's Island than elsewhere, if the above narratives of Governor Butler and Mr. Hughes were correct. That the latter referred to the cahow, though he did not mention the name of the 'silly birds,' may be properly inferred, because of the season, 'beginning of the newe yeare,' when the large party of starving settlers was sent there for food. The egg-birds did not arrive until the first of May. This famine and the sending of a large number of starving persons to feed on the defenceless birds, at their breeding season, was unquestionably the direct and principal cause of their rapid extermination, for it was during the very next year (1616) that the first law was passed, 'but overlate,' restricting the 'spoyle and havock of the cahowes.' We were unable, for lack of time, to dig for the bones of the cahow on Cooper's Island. The loose ground there is full of the holes of two species of large land crabs. Such holes may have served the cahow for nesting places.

PSYCHIATRY—ANCIENT, MEDIEVAL AND MODERN.

By FREDERICK LYMAN HILLS, M.D.,
NEW HAMPSHIRE STATE HOSPITAL.

"Forth from my sad and darksome cell,
Or from the deepe abysse of hell,
Mad Tom is come into the world againe
To see if he can cure his distempered braine."
—Old Tom O'Bedlam Song, XVII. century.

AMONG the achievements of the nineteenth century none surpass the revolution wrought in the field of psychiatry. The care of the insane to-day excites the interest not only of philanthropists and alienists, but of all right-minded men and women. "No reflecting mind," says Letchworth, "can be indifferent to the question of making proper public provision for the treatment and care of those afflicted with an insidious disease from which no measure of intellectual or physical strength or worldly prosperity affords any certain immunity —a disease, which, prone to feed upon excitement, finally transforms the noblest faculties of our race into a wreck so appalling that in its contemplation the human intelligence becomes bewildered and dismayed. At no time in the history of civilization has the importance of this subject been more thoroughly acknowledged; and probably at no time have influences contributory to mental derangement been more powerful than they are to-day." It is eminently profitable at this time to review the treatment of the insane in ancient days, to recall the misfortunes of the unhappy madman during the dark ages of history, and to note the gradual evolution of the psychiatric science of to-day.

Going back into the very dawn of history we find scattered references to the treatment of madness, which was looked upon as a punishment by the gods or ascribed to demoniacal possession. The earliest known historical reference to insanity occurs in Egyptian papyri of the fifteenth century B. C. In one of these, according to Mahaffy, music is spoken of as employed in the treatment of insanity, and many formulæ are given for the cure of diseases caused by an evil spirit dwelling within the body. Probably the next earliest record is that found in Hebrew history, referring to the same therapeutic agent, this time used to calm the troubled spirit of Saul (1055 B. C.). In the first book of Samuel we read: "When the evil spirit was upon Saul, that David took a harp and played with his hand; so Saul was re-

freshed and was well and the evil spirit departed from him." The legendary history of Greece affords numerous instances of madness, but as to the treatment in these early times there is only eloquent silence. The belief in demoniacal possession was prevalent among all primitive peoples, furnishing a clue for such treatment as was anywhere attempted, and this belief, giving way a few centuries later to a partial realization of the physical basis of insanity in the best medical minds, recurs again in the darkness and decadence of the middle ages but magnified and rendered terrible by the ignorance and gross superstitions of the time. In ancient Egypt, demons were exorcized and lunatics purified in temples dedicated to Saturn. The god Khons is said to have answered prayers for the cure of an Asiatic princess. The priests of Egypt, who were also physicians of the day, were not unmindful of the benefit of hygienic measures and combined with them the charm of music and the influence of the beautiful in nature and in art.

No reference is made in the literature of antiquity to places set apart for the care of the insane. In Greece they were sometimes cared for by the priests in the temple of Aesculapius. More often they were detained at home by their friends if dangerous, or allowed, if mild, the freedom of the country unrestrained and unmolested. Many of the soothsayers, sorcerers and sibyls of these days were undoubtedly insane, and the mental condition of some was known to those who sought their offices. Restraining devices were generally used in all violent forms of madness. Herodotus relates that Cleomenes (519–491 B. C.), king of Lacedæmon, becoming insane, was imprisoned by his kindred and his feet put in the stocks. While so bound he asked the man left to watch him for a knife. This being refused he began to threaten the man, who, becoming frightened, gave him the knife and he at once made repeated gashes in his limbs and abdomen until he died.

In the time of Euripides (480–406 B. C.) it would appear from his account of the madness of Hercules that madmen were bound with cords and fastened to the nearest convenient spot. Hippocrates, the Father of Medicine (460–377 B. C.), described three forms of mental disease and seems to have recognized alcoholic insanity. He was the first to lay stress upon the physical basis of insanity and ridicules the treatment given by the priests. He used phlebotomy, purgatives, emetics, baths, a vegetable diet, exercise, music and travel. He regulated the use of hellebore, a drug held in high esteem from the dawn of history. Writing to Democrates he said: "Hellebore when given to the sane, pours darkness over the mind, but to the insane it is very profitable." This drug was believed to act powerfully in cleansing and invigorating the intellectual faculties. It is said that Carniades, the

Academic, when preparing to refute the dogmas of the Stoics, went through a course of purgatives by hellebore. Melampus, son of Amythaon, is said to have cured the daughters of Proetus, King of Argos, of melancholy, by purging them with hellebore. According to tradition Melampus had observed that the goats who fed on this plant were purged, and having administered it to the king's daughters, who were wandering in the woods under the delusion that they were cows, he cured them and received the hand of one of them in marriage and a part of the kingdom of Argos as his reward. So celebrated was this medicinal agent as a mental remedy that the poets of antiquity sang its praises. Horace, in allusion to the 'happy madman,' says:

> **He, when his friends at much expense and pains,**
> **Had amply purged with hellebore his brains,**
> **Came to himself—"Ah, cruel friends!" he cried,**
> **"Is this to save me? Better far had died**
> **Than thus be robbed of pleasure so refined,**
> **The dear delusion of a raptured mind."**

Persius thus addresses Nero in his fourth satire, telling him to relinquish the arduous duties of government:

> **"Thou hast not strength, such labors to sustain,**
> **Drink hellebore, my boy—drink deep and purge thy brain."**

Hippocrates had his patients collect this medicine themselves at Anticyra, in Thessaly, and thus made its use an incident of a very hygienic course of treatment. In cases of suicidal melancholia he employed mandragora, first spoken of by him in the treatment of this disease.

The attitude of the state toward the care of the insane at the period soon after the death of Hippocrates is thus expressed by Plato (375 B. C.) in 'Laws of the Republic': "If any one is insane, let him not be seen openly in the city, but let the relatives of such a person watch over him at home in the best manner they know and if they are negligent let them pay a fine."

The teachings of Hippocrates and his followers were probably the guide for those who had to do with the insane during the next two centuries, and nothing further appears in medical literature until the careful study of insanity made by Asclepiades of Bythinia (100 B. C.). He distinguished between illusions and hallucinations, noted the changing mental states of individual cases and made some innovations in the treatment. He recommended his patients to be placed in the light rather than confined in dark rooms or cells, disapproved of venesection, and of the fomentations of poppy, mandragora or hyoscyamus. He prescribed abstinence from food, drink and sleep in the early part of the day; the drinking of water in the evening; that gentle friction

should be employed and, later on, liquid nourishment should be administered and the friction repeated. By these means it was his hope to induce sleep. Themison, his disciple, prescribed a more liberal diet, baths and astringent fomentations. Another of his disciples recommended stripes in the treatment of the insane, but it is doubtful if this was sanctioned by the master. Asclepiades also attempted substitutive medication, advising intoxication in the general treatment of insanity.

Celsus (A. D. 5) formulated wise rules for the hygienic and moral treatment, but unfortunately advised also the use of hunger, chains and chastisements to subjugate the patient. He would have those scolded whose mirth was excessive and resort to torment should conciliation fail. To startle a patient suddenly, to terrify him, this was excellent. But he directed that all things possible should be done to divert the melancholy and to excite cheerful hopes. Pleasure should be sought in fables and in sports, in music and in reading aloud. To quiet the excited and to favor sleep, he made use of a rocking motion and the sound of a waterfall.

Aretaeus (A. D. 80) gave a detailed description of mania and melancholia, considering the latter to be the incipient stage of the former. Little is known as to his methods of treatment, except that he does not mention restraint in his descriptions.

Galen (A. D. 150), the celebrated advocate of the humoral pathology, gives little as to treatment, but his theory of insanity is interesting. Moisture, he says, produces fatuity, dryness sagacity, and therefore the sagacity of a man will be diminished in proportion to the excess of moisture over dryness. Therefore preserve a happy medium between these opposite qualities, use venesection if you think the whole body of the patient contains melancholy blood. Bleeding must be avoided if madness arise from idiopathic disease of the brain.

Then follows Coelius Aurelianus (A. D. 195), leaving a most remarkable treatise on the treatment of insanity, preaching gentleness and humanity, skilled attendance and non-restraint. He thus expresses himself regarding the physicians who resort to harsh methods of treatment: "They seem rather to lose their own reason than to be disposed to cure their patients, when they liken them to wild beasts who must be tamed by the deprivation of food and the torments of thirst. They go so far as to counsel bodily violence and blows, as if to compel the return of reason by such provocations, a deplorable method of treatment that can only aggravate the patients' condition, injure them physically, and offer to them the miserable remembrance of their sufferings whenever they recover the use of their reason." He taught that the patient should be put in a quiet room, moderately warm and light, excluding everything of an exciting nature. The bed

should be firm and fixed to the floor and should have a straw mattress. The attendants should be carefully instructed. "If the sight of other persons irritates them and only in very rare instances, restraint by tying may be employed, but with the greatest precaution, without any unnecessary force, and after carefully protecting all the joints and with especial care to use only restraining apparatus of a soft and delicate texture, since means of repression employed without judgment increase and may give rise to furor instead of repressing it." He used fomentation by applying warm moist sponges over the eyelids to relax them and influence the circulation in the membranes of the brain. He advised emollient and astringent applications, the latter made of galls, alum, etc., soothing and invigorating poultices, baths of oil and natural hot baths. He denounced abstinence and ordered a full diet. He spoke against the practice of making the patient intoxicated, the use of hellebore, of aloes and of venesection. During convalescence he recommended farming, walking, riding, singing and theatrical entertainments. In the latter scenes of a solemn and tragic character were to be enacted to guard against excitement.

With the passing of Galen and Coelius Aurelianus the sun goes down into the black clouds of ignorance succeeding the fall of the Roman Empire; and the lunatic is left to drag out a miserable existence, generally neglected and alone throughout the dark centuries following, to and through the middle ages. There is a fitful gleam faintly illuminating the scene momentarily as when Alexander of Tralles (A. D. 560), or Paulus Aegineta (A. D. 630) reiterates the teachings of Aurelianus, but they lay stress more upon the medicinal than the hygienic treatment and are forgetful of his admonitions against chains and imprisonment. The earliest hospital for the insane known was founded in Jerusalem in the fifth century as a refuge for anchorites whose minds became affected through their penances.

The middle ages are defined by Hallam as dating from the invasion of France by Clovis at the end of the fifth century to the invasion of Naples by Charles VIII. at the end of the fifteenth. During the first half of this period there seems scarcely to have been any intellectual or political development. The whole of Europe was, almost without exception, sunk in the darkest ignorance and the most wretched barbarism. In some countries the awakening was earlier than in others, but the darkness did not anywhere die out at once. As gradually the clouds began to lift and the signs of returning light were here and there discernible only a fraction of a special class, a limited portion of the clergy, were in any way affected, and the mass remained for long bound down by servility, ignorance and superstition. "The struggle among the races for the possession of the countries that had been loosed from the Roman yoke," says Sibbald, "'continued for centuries

to make the state of war persistent and almost universal." When not in conflict with their neighbors, the constant friction and strife within the individual states still prevented organization and natural development. "In such a state of society little thought could be bestowed on anything which did not directly relate to the fierce struggle for very life in which every state and every individual was engaged." There was no time for philanthropy, for the care of the suffering, for the relief of the poor, for comforting the sick in body or mind. Slowly the leaven of christianity was at work, a silent force effecting slow but deep-rooted changes in the constitution of society, beginning about the eleventh century to gradually bring about the abolition of slavery and exerting an influence in instituting some sort of provision for those whose mental condition was thought to be the result of disease. The monks were also the physicians during the dark ages and the monasteries offered quiet retreat and seclusion for many insane, together with sympathy and protection which could not be found elsewhere. Spiritual agencies were everywhere popularly believed to be most efficacious in the cure of madness, and many and long were the pilgrimages made to the shrines of those saints who were believed to have special influence over the mentally afflicted, and many miraculous cures were said to have been brought about through exorcism and prayer. There were many wells through Europe and the British Isles, each with its particular saint, to which the insane were brought to bathe and to pray. At St. Nim's Pool in England, it was the custom to plunge the patients backwards into the water and drag them to and fro until their excitement was subdued. If they showed signs of recovery thanks were offered in a neighboring church, but if not, the treatment was continued until no hope remained. From the seventh century even to the present day lunatics have made pilgrimages to the shrine of St. Dymphna at Gheel, and here the first colony for the insane originated through a slow process of evolution, and stands to-day as the best representative of the community or family system of caring for the insane.

So great a part did superstition and religious bigotry play in the treatment of insanity that the estate of the lunatic grew ever worse. Any man who exhibited anything unusual in conduct or language was at once suspected by his neighbors of necromancy or commerce with the Devil and looked upon with suspicion. Any manifestation of peculiar genius, the display of inventive ability or promulgation of a new doctrine rendered a man liable to torture, imprisonment or death. The belief in demoniacal possession, and witchcraft, was distinctly recognized in the Bible and fostered by the church. All over Europe persons undoubtedly insane were burned or hanged as witches or were whipped in the public squares to drive out the evil spirits.

Pope Innocent VIII. in 1488 appointed inquisitors in every country armed with apostolic power to find and punish those of whom he thus declared: "It has come to our ears that numbers of both sexes do not avoid to have intercourse with the infernal fiends, and that by their sorceries they afflict both man and beast. They blight the marriage bed; destroy the births of women, and the increase of cattle, they blast the corn in the ground, the grape in the vineyard, the fruit of the trees, and the grass and herbs of the field." Thus stimulated by the church the search for persons punishable for these crimes was everywhere successful. It is probable that one-fourth of the 40,000 persons executed for witchcraft during the first eighty years of the seventeenth century in England alone were insane. Among the thousands of persons tortured, burned and hanged as heretics there were doubtless many who, infected by surrounding fanaticism and carried away by exceptional beliefs, were really the victims of mental disease.

Persons afflicted with the more quiet forms of insanity without excitement were often regarded as suffering in punishment for sin and were accordingly treated by fasting, pilgrimages and self-castigation. Some, the possessors of a certain shrewdness and drollery, were received into private houses and cared for, partly from charity, and partly because of the amusement to be derived from their eccentric speech and conduct. The conditions were practically the same in all European countries with the exception of Italy and Spain, where insane asylums were established during the latter part of the middle ages.

The Mohammedans preceded the Christians in the establishment of asylums for the insane, and it is probable that as early as 1300 A. D. this form of charity was general in Mohammedan countries. A writer of the seventh century notices the existence of several such institutions at Fez. The asylum in Cairo was founded in 1304 A. D. Whether or not the Christians obtained the idea of the organization of such asylums from the Mohammedans, it is of interest to note that they are first found in Europe among those nations nearest to the Mohammedans and most subject to their influence. To Spain is due the honor of establishing the first asylum in Christian Europe for the care of the insane exclusively. This was opened in Valencia in 1409 A. D. by a monk, Juan Gilaberto Joffre, who was moved by compassion on seeing maniacs driven through the streets by hooting crowds of men and boys. The treatment in these early establishments amounted to little more than seclusion and restraint, though the monks in charge of the asylum at Saragossa, established in 1425 A. D., had some conception of a rational open air treatment. Asylums were also opened at Seville and Valladolid in 1436 A. D. and at Toledo in 1483 A. D. "Two other very honorable facts may be mentioned," says Lecky, "establishing the preeminence of Spanish charity

in this field. The first is that the oldest lunatic asylum in the metropolis of catholicism was that erected by the Spaniards in 1548. The second is, that, when at the close of the eighteenth century, Pinel began his great labors in this sphere, he pronounced Spain to be the country in which lunatics were treated with most wisdom and most humanity."

In the twelfth century madmen were taken to St. Bartholomew's in London and, according to the monkish narratives many wonderful cures were effected. Up to the sixteenth century monasteries and prisons and ecclesiastical hospitals contained cells into which lunatics were received, but it is probable that they were given little care or treatment and that the public at large was the chief beneficiary by their incarceration. In 1547 the first lunatic asylum not under ecclesiastical administration was established in England. The priory for the order of St. Mary of Bethlehem founded by Simon Fitzmary, a sheriff of London, in 1247, in St. Botolph's without Bishopsgate, London, had for a century and a half been used for the reception of lunatics. In this year the institution, for long before called Bedlam, was transferred by Henry the VIII. to the authorities of the city, with an order that it be converted into a house for the reception of lunatics. It stood in an out of the way place, close to many common sewers and accommodated but fifty or sixty patients. For very many years, however, the place remained a 'horrible prison,' says Sibbald, 'and not a hospital in any sense of the word.' "Up to the year 1770 the patients were exhibited to the public like wild beasts in cages, on payment of a penny, and they are said to have afforded much sport to the visitors who flocked to see them in numbers estimated at not less than 48,000 annually. Some whose condition was so ameliorated that they were no longer considered dangerous to the public were licensed to go begging. On their left arm was placed an armilla—an iron ring for the arm about four inches long, which they could not get off." "They wore about their necks," says Aubrey, as quoted by Disraeli, "a great horn of an ox in a sling or bawdry, which when they came to a house they did wind; and they put the drink given them into this horn, whereto they put a stopple." In a Tom of Bedlam song which dates from the first part of the seventeenth century, the comforts of his asylum life are thus alluded to by the licentiated beggar:

In the lovely lofts of Bedham
In stubble soft and dainty,
Brave bracelets strong,
Sweet whips ding dong,
And a wholesome hunger plenty.

About 1675 when the licensing of beggar lunatics was stopped by law, a new Bedlam three times the capacity of the old was erected in

Moorfields, the necessity for increased accommodations becoming greater 'as the country came more and more into systematic government and as the wholesale burning of such unfortunate persons as wizards or witches died out.'

Little appeared in medical literature during this period upon the care of the insane. Daniel Sennert (1572–1637) wrote sensibly upon mania and melancholia, but left nothing as to treatment, except to bleed and to purge. Sydenham (1624–1689) had little to say on mental affections. An adherent to the current doctrine, he attributed insanity to a disabling of the 'animal spirits' by a prolonged fermentation. He prescribed a cordial of Venice treacle, containing the flesh and broths of vipers, amber and sixty-one more ingredients in Canary wine and honey to be given three times a day, the patient to remain in bed and to be liberally supplied with liquids. For ordinary mania he ordered the withdrawal of nine ounces of blood on two or three occasions with three days' interval between each bleeding. A course of pills of colocynth and scammony followed, and on the days when the patient did not take the pills he was to have an electuary composed of conserve of monk's rhubarb, rosemary, candied angelica and other pleasant ingredients.

Something more rational was attempted in Paris when by an Act of Parliament in 1660 the insane passed through two wards, especially reserved for them in Hotel Dieu, the ward St. Louise for men containing ten beds for four each and two small beds; the ward St. Martin for women containing six large beds and six small ones. Treatment here was by means of douches, cold baths, repeated bleedings, hellebore, purgatives and antispasmodics. If there was no improvement in a few weeks they were sent to the Petits Maisons, the Salpêtrière or the Bicêtre, where they were kept clothed in rags, confined by chains, poorly fed, bedded on rotten straw, often in cells infected with disease. As in England on holidays they were exposed to the gaze of the public, admitted for a small fee as to a menagerie. In 1667 Dennis, in Paris, successfully employed transfusion of blood taken from a calf in the case of a young man insane after an unhappy love affair.

The early years of the eighteenth century saw the gradual evolution of the asylum idea and the slow increase in the number of establishments for the insane, founded not only by the state but by private individuals. The condition of the insane in the latter was particularly distressing for many years, and, even until well on in the last century, many of them were more to be dreaded than the larger public asylums.

Dean Swift had in mind the foundation of a hospital for the insane as early as 1731 when he wrote the verses on his own death and described his determination thus,

He gave the little wealth he had
To build a house for fools and mad;
And shewed by one satiric touch,
No nation wanted it so much.

This object he had afterward always in mind, and, although suffering much for several years and his mind finally becoming affected in 1742, he made plans for its establishment and, dying in 1745, left his whole property, about $60,000, for the founding of St. Patrick's Hospital in Dublin, which was opened in 1757 for the reception of fifty patients.

The methods of treatment employed in the middle of the eighteenth century are thus set forth by Dr. Richard Mead, physician to George II. in his "Medical Works" (1762). "Authors, both ancient and modern, recommend a great number of medicines, some which are suitable to maniacal, others to melancholy patients; but both sorts agree in the property of correcting the bile, which is acrid at first, then becomes viscid and black as pitch. Moreover the very blood in this disorder is thick, fizy and black. Now it will be observed that most of the medicines proper to be given in this disease are in some degree endowed with the property of opening and scouring the glands and increasing perspiration. Of this kind are the strong-smelling gums, specially asafœtida, myrrh, Russian castor, and camphire, which last is asserted to have an anodyne quality and to procure sleep with greater certainty and safety than opium. In melancholic cases chalybeats are also very proper. In fine, a frequent use of the cold bath is very serviceable, especially in maniacal cases. For nothing, as Celsus says, is of such benefit to the head as cold water." He cautions against the use of stripes or other rough treatment as unnecessary, binding alone being sufficient to restrain the maniacal, who 'are all cowards.' He attempted to stop the ill-timed fits of laughter of some by chiding and threatening; to dissipate the gloomy thought of others by music and such diversion as they formerly took delight in. He cautioned the physician to attend carefully to the free action of the bowels and kidneys and instead of applying blisters to the head he says, "Better in imitation of the ancients to shave the head, and then rub it with vinegar in which rose flowers or ground-ivy leaves have been infused; and also to make a drain by passing a seton in the nape of the neck, which is to be rubbed with a proper digestive ointment and moved a little every day, in order to give a free issue to the purulent matter." He ordered slender diet, mostly of gruels and meats easy of digestion, disapproved of giving anodynes to procure sleep and recommended walking, riding, playing at ball, swimming and travel by land or sea in convalescence.

The latter part of the eighteenth century witnessed an awakening

of the minds of men throughout the civilized and enlightened nations of the world to a realization of the man's duty to his fellow man. The dissemination of knowledge among the people was gradually killing out the grosser forms of superstition, holding such a hypnotic influence over the ignorant. The spirit of liberty, fraternity and equality was abroad. With this zeal for the acquirement of knowledge, the spirit of investigation and the kindling of enthusiasm for scientific research, philanthropic ideas began to develop in men's minds, pity for the suffering and the unfortunate and a desire to better the condition of all. Prison reform was agitated, hospitals were organized for the sick in body. The treatment of the insane was made a matter for legislative investigation and although little or nothing was done toward the immediate relief of their condition, yet public sentiment was being slowly aroused in their behalf. Gradually the light of a brighter day was dawning. The propriety of abusive treatment, of cruelty, of chains, of stripes, formerly regarded as essential for the control of the maniac, or looked upon with indifference, was now brought into question. Much was written relative to insanity during this period but no decided step was taken for the betterment of conditions until near the close of the century when the noble-hearted Tuke, in England, and the brave Pinel, in France, started the grand reform, broke the fetters and brought the great restorative, hope, to stimulate the weakened mind.

The York Asylum, founded by general subscription in 1777, for 'the decent maintenance and relief of such insane persons as were in low circumstances' was, about 1791, the worst among the bad institutions in England. In this year a young woman, a member of the Society of Friends was committed to the York Asylum. Her friends were denied the privilege of seeing her and in a few weeks she died. Her death arousing suspicion of improper treatment among the Friends, one of their number, Mr. William Tuke, "resolved (1792) to establish an institution in which there would be no secrecy and where the patients would have humane and judicious care." Thus was the Retreat at York established and, in 1796, launched upon its memorable career, continuing from the first a leader in psychiatric progress.

The year 1792 also is made memorable by the appointment of Philip Pinel as physician to the insane at the Bicêtre. Coming to this position a trained alienist, he was deeply stirred by the condition of the men confined there, fifty of them in chains, many for a long period of years. His repeated and persistent appeals to the Commune for authority to release them from their bonds were finally given a reluctant affirmative answer, and in the end he was able to remove the chains from all the patients and to continue the good work at the Salpêtrière, an institution exclusively for women.

Turning now to our own country we find the care of the insane in the American colonies prior to the Revolution to differ in no way from the treatment during the same period in Europe. In the Old Colony Laws of Plymouth (1660) provision was made that persons who commit suicide "shall be denied the privilege of being buried in the common burying place of Christians, but shall be buried in some common highway, where the selectmen of the town where such persons did inhabit, shall appoint, and a cartload of stones laid upon the grave, as a brand of infamy, and as a warning to others to aware of the like damnable practice." In jails, almshouses and the outhouses of private dwellings, the insane were kept, often in chains and in filth, and deprived of light and proper warmth. No attempt was made toward special provision for them until 1745, when an asylum was erected in New York City, on the spot where the City Hall now stands, for the reception of the 'indigent poor, the sick, the orphan, the maniac and the refractory.' But the first institution in America for the remedial treatment of the insane was founded in 1751 in connection with the Pennsylvania Hospital. Being opened 1752, "it was," says Kirkbride, "for a long period of years far in advance of all other receptacles for the insane in the United States, and, having the advantage of physicians like Bond, Shippen, Rush, Wister, Physick and others of equal ability, its wards were constantly filled, and its advantages eagerly sought by patients from the most distant parts of the Union."

It is noteworthy that, besides Dr. Thomas Bond, of Philadelphia, and Benjamin Franklin, the Society of Friends was active in the inception of this hospital, a society later to be influential in the establishment of the York Retreat in England and the Friends Asylum at Frankfort, Pa. (1813), showing in these early times a more enlightened philanthropy than any other religious body and giving the impetus to a movement which in the early years of the nineteenth century was to effect a revolution in the treatment of the insane.

The first governmental institution in America was erected by the province of Virginia at Williamsburgh in 1773; but it was not until the era of peace and quietude following the wars of the Revolution and of 1812, and after the successful inauguration of the state governments that public sentiment became thoroughly aroused to the necessity of better care for these unfortunates, and state institutions sprang into existence. During the thirty years following the war of 1812 twenty-three public and private asylums were opened in the United States.

The treatment at this time was largely influenced by the writing of Dr. Benjamin Rush, a man of great intelligence and benevolence whose 'Observations on Diseases of the Mind' (1812) contained much of

value as to the moral treatment of the insane, but who was behind Pinel in realizing the advantage of kind treatment and the harmfulness of restraint. "A prevailing error found in his writings on insanity," says a writer in the 'American Journal of Insanity' (Vol. 4) "is that the insane are to be disciplined and governed, that those who have the care of them must obtain dominion over them by fear or by other means that we may think improper." He says that the physician on entering the chamber of the deranged person should first 'catch his eye and look him out of countenance.' After trying many ways to obtain obedience he says, "If these prove ineffectual to establish a government over deranged persons, recourse should be had to certain modes of coercion." Among them were the straight jacket, the tranquilizing chair (invented by a Dr. Darwin and consisting of a stout post revolving on a pivot and bearing a chair into which the patient was bound in the longitudinal position when a sedative effect was desired or in an erect position to secure intestinal action), the withdrawal of pleasant food and pouring cold water down the coat sleeves. "If all these modes of punishment should fail of the intended effect," he adds, "it will be proper to resort to the fear of death."

But the man who did more than any other, probably, to forward the humane care of the insane, was Esquirol, who succeeded Pinel at the Salpêtrière in 1810. Devoting himself with zeal and with singleness of purpose to this ministration, he brought about still greater reforms in the housing, the regimen and medical care of the insane, and in 1817 gave the first course of lectures ever delivered on insanity. These were largely attended every year by physicians from all countries. He traveled through France investigating everywhere the condition of the insane, arousing the interest of the magistrates and, through his reports to the superior authorities, causing the abolition of many abuses and much misery. He saw ten asylums opened in France and the insane taken from 'their narrow, filthy cells, without light and air, fastened with chains in these dens,' in which he found them, and placed in asylums where the use of chains was abandoned, where walks and gardens were accessible, and where beds and good food were provided and the attendants did not go 'armed with sticks and accompanied by dogs.'

The same spirit of progress was now abroad in every enlightened country of Europe and in America. Asylums were built, treatises upon mental medicine became more numerous, classification of mental disease and more careful clinical studies were attempted, societies were organized for the study of insanity and periodicals appeared whose pages were given wholly to the discussion of psychiatric subjects and the propagation of the new doctrines.

"In the period which elapsed from 1830 to 1850," says Letchworth,

"great and rapid advances were made throughout the United States in methods of caring for the insane. The reforms then accomplished attracted the attention of Europe, and it may be said, without any egotism, that they were in advance of contemporary progress in other countries." Much of this reform was due to the exertions of Dorothea L. Dix, who about 1837 began a career of remarkable success in arousing public attention and securing legislative action for the betterment of the condition of the insane. She is said to have been influential in the establishment of thirty-two asylums for the insane. But unfortunately this high standard of achievement was not maintained. During the civil war and the early period of reconstruction this reform suffered a reaction, and the country failed to keep pace with the progressive movement in other lands. Within the last thirty years of the century, however, rapid advance was made, and to-day the standard of work done for the insane in America is not lower than that attained in other countries.

The period of large and imposing buildings, palatial in exterior appearance, has passed. The buildings erected twenty or thirty years ago were uniformly massive, three- or four-story structures, the interiors often monotonous and cheerless. To-day the tendency is to place the patient in surroundings as cheerful and homelike as possible. To have smaller buildings, comfortably furnished, with pictures on the walls, with books, games and the means for light amusements and employment. No longer is the patient forced to pace ceaselessly long cheerless corridors, the walls lined with benches and heavy chairs and bare of all adornment.

Now, instead of large blocks of buildings, the modern hospital consists of a group of cottages, best of two stories, separated or connected by a low corridor. Here the patients are separated into small groups carefully classified as to their mental condition. These buildings are surrounded by nicely kept grounds, with green lawns dotted with shrubbery and flowers. There are groves to afford a shady retreat, and here the patients spend much time every pleasant day. Many of them have the parole of the grounds and come and go without oversight. Freedom is allowed as far as is consistent with safety. In many places the usual iron gratings have been removed from the windows and doors left unlocked.

But the institutions for the insane of to-day are not places merely of detention. The insane asylum, except for the chronic cases, in most states both here and abroad, has passed away and in its place has arisen a hospital to which the patient comes as a sick man to have the kind care and systematic treatment that the word hospital implies. He is received and cared for by nurses trained to the work and is at once impressed with the idea that he is a sick man, so regarded by his fellow

men, if not cognizant of it himself, and that he is to have done for him what careful nursing, hygienic surroundings and medical science can do. The perfection to which this system has attained varies much in different states; but all are tending to the same end, and ere long the care of the acute insane in all enlightened lands will be based upon the same scientific plan. At the present time in Europe and America there is great activity within the walls of the hospitals for the insane. The study of the individual patient is more thorough than ever before. Not only are his mental symptoms diligently watched and recorded, but a careful systematic examination of all his bodily functions is undertaken. For this purpose laboratories are equipped and men trained to microscopical and chemical analysis are being more and more employed to carry on the work. The study of the physiology and pathology of the nervous system is being assiduously pursued and recent epoch-making discoveries in tissue-staining have stimulated this work, causing almost a revolution in the theories of nervous action; and it would seem that a better understanding of the functioning of the central nervous system was dawning. The defects of distant organs, of the blood vessels, the blood, the lymph and all abnormal bodily conditions, are known to often have a deleterious effect upon the nervous system and improvement in the mental condition to be coincident with their removal. The physician and the surgeon, the neurologist, the psychologist, the chemist and the pathologist are all at work hand in hand with the alienist to cure him who is the unhappy victim of mental disease.

In the modern hospital such moral measures are brought into operation as the companionship of a kind and congenial nurse, cheerful environment, the use of the minimum amount of restraint consistent with safety and efforts to amuse and divert the attention of the patient away from himself and his troubles, the attempt to arouse an interest in some light employment and the suggestive influence of a hopeful spirit. The therapeutic effect of exercise, massage, hydrotherapy and electrical influence are all called into use, and the medical treatment is directed to any complicating disorder of the bodily functions. No part is overlooked. The physical machine is restored as far as possible to working order in the hope that mental restoration will be the consequence. In a hospital thus conducted harsh or abusive treatment means the immediate dismissal of the offender.

The selection of an efficient corps of attendants is a matter of the greatest importance. Much improvement has been brought about by the establishment of training schools in hospitals for the insane with systematic instruction in the duties of the nurse. In a large and well organized institution an attendant entering the school is in a position to obtain instruction of so much general usefulness in the

treatment of the sick that the hospital benefits not only by the more efficient service rendered, but also by the attraction of a superior class of applicants for the positions. "Much has been accomplished in rescuing the insane from chains, gloomy cells and scourgings," says Letchworth, "but the measure of reform in their behalf will not be complete until there is no possibility of their being subjected to the humours of ignorant, unfeeling and incompetent attendants." That training schools are an efficient means of accomplishing this reform there can be no doubt.

A most notable advance in the treatment of the insane was the introduction of the system of non-restraint—the disuse of all mechanical devices for restraining the freedom of bodily movement. This was first demonstrated to be practicable by Mr. Gardner Hill at the Lincoln Asylum, England, in 1836, and Dr. Connolly put the system into full operation at Hanwell in 1840. At first ridiculed as "the freak of an enthusiastic mind, that would speedily go the way of all such new-fangled notions" it was bitterly opposed for years by the superintendents of the large county asylums of England, and to Dr. Connolly is due the honor of having demonstrated its practicability and of having overcome after a prolonged struggle the opposition and prejudice against it. Men like Todd, Woodward, Butler, Ray—names memorable in the history of American psychiatry—were not unmindful of the remedial value of sympathetic and kindly treatment, and, while the controversy over non-restraint was waged abroad, were independently carrying out the same humane doctrine and conducting their institutions on the same 'enlightened principles of conciliation and kindness.' At the present day the system of absolute non-restraint is more in vogue in England than here where the necessity for some form of restraining appliance is still maintained to exist in certain instances. But it is evident from the annual reports of the American hospitals that the use of restraint is lessening each year. In some institutions it is entirely abolished; in all it is used to a very limited extent and only upon the order of the attending physician. The means of restraint employed consist chiefly of the canvas camisole to restrain the movements of the hands and arms, the canvas or leather muff for the hands and the use of a strong sheet fastened across the bed if the patient is not in a conditon to be up and about the rooms. In place of the sheet the hands and the feet may be restrained while the patient is in bed by soft rolls of cheesecloth.

The most recent advance in the care of the acute insane is in the movement toward the establishment of psychopathic hospitals for treatment and for clinical and pathological research in or near the large centers of population. In this most advanced work Europe has taken the lead, and such hospitals have been in existence for some years in

the university towns of Germany and Austria. That at Giessen, opened in 1896, is thus described by Dr. Frederick Peterson, president of the New York State Lunacy Commission—"It is in the town of Giessen, near the other hospitals used for teaching purposes, adjacent to the pathological institute, and consists of ten or eleven cottages for 116 patients, in a beautiful garden. The central building contains pathological, chemical, microscopical, photographic and psychophysical laboratories, besides a mechanical workshop, clinical auditorium, library, and a dispensary or polyclinic for outdoor patients. The necessary administrative offices and rooms for the director and assistant physicians are also here. There are cottages for private cases, and for quiet, suicidal, restless, and disturbed patients of each sex. This is probably the most complete hospital of its kind in existence at the present time." Although as yet in Great Britain and America this work has not received the attention it merits, a beginning is being made. At Albany, New York, a pavilion has been opened in connection with the Albany General Hospital for the reception of the acutely insane, and in Michigan the last legislature passed an act to "Provide for the Construction of and Equipping of a Psychopathic Ward upon the Hospital Grounds of the University of Michigan." In Boston and Philadelphia out-patient departments have been in successful operation for several years. There is no doubt but that the next few years will see the general opening of such hospitals and out-patient departments in the larger cities throughout the country.

Another movement that is ripening to fruition in America is that for the establishment of 'After-care Associations' for the protection and help of needy patients upon discharge from hospitals, recovered, but without means of support. This idea originated in Germany as far back as 1829, with Hofrath Lindpaintner, who organized in that year a 'Society of Patronage' which exercised a paternal care over, and rendered assistance to, such persons for a period of two years following their recovery. Such associations were later formed in France, and in recent years the system has been in general operation in Germany, France, England and notably in Switzerland. The work of these organizations, the establishment of which in this country has already been discussed by the American Neurological Association, consists in finding proper homes and employment for discharged patients, maintaining a general supervision over them and offering such financial or other aid as may be necessary again to put them in the way of earning a livelihood.

In spite of all efforts put forth to cure the acute mental troubles a large percentage of the cases prove rebellious and drift into chronic states of mental deterioration. The patients do not die, but live in good bodily health with intellect dulled to the higher interests of life

and sink slowly into incurable dementia. Other cases are marked from the outset by the stigmata of chronicity, being slow and insidious in development, and the disease is often fully established before the patient's friends awake to a realization of the event. These chronic classes of the insane require a specialized treatment, a home where they can be protected from the world and from themselves, where congenial occupation may be obtained, where a strict but humanely enforced control may be exercised over their conduct and where their lives may be lived in comfort and in peace. Until recent years all classes of insane have been cared for in large institutions where proper classification has been difficult or impossible and where the acute and curable cases have been in daily contact with the incurable and the demented.

Of late much effort has been made to overcome this objectionable state of thing by the establishment of colonies, where the chronic insane may live in small separated cottages scattered in groups over a large tract of land. Here the patients live in small groups or families under conditions more approximating home surroundings. The farm and industrial shops furnish the occupation so necessary to relieve the monotony of life and to counteract abnormal tendencies. The little colony has its chapel and amusement hall, sometimes a store, and furnishes an environment in which a man may live in comparative comfort and with a reasonable degree of contentment. Such colonies are now quite numerous in Europe and America and seem to furnish ideal conditions for the care of the chronic and presumably incurable cases. In Scotland, Germany, Belgium, and to a limited extent in Massachusetts, a system is in operation with a fair degree of success in which selected chronic cases are boarded out in private families in the country districts while under the observation and control of a governmental bureau or commission.

It is unfortunately a fact that many of the chronic insane are still detained in almshouses and poor farms not only in this country but abroad. Here they, who are the unfortunate victims of disease and not to be held responsible for their condition, are obliged to associate with paupers and criminals and are kept in a condition unworthy of the civilization of the twentieth century. The cruelty of a past age still lingers in many of these places, and not only do they suffer from the stigma of their associations, but are too often the victims of improper and insufficient attendance and are not strangers to bonds and chains.

But the grand work of emancipation is still going on, and enlightened public sentiment is everywhere at work and the realization of a fuller charity is surely not long to be delayed. At the beginning of the twentieth century we are on the threshold of a new era in the working out of this great problem, and the scientific and philanthropic spirits of the day are laboring together and energetically toward its ultimate solution.

THE NATIONAL CONTROL OF EDUCATION.*

By the Right Hon. Sir JOHN E. GORST, F.R.S.

THE invitation of the British Association to preside over the Section of Education, established this year for the first time, has been given to me as a representative of that government department which controls the larger, but perhaps not the most efficient, part of the education of the United Kingdom. The most suitable subject for my opening address would therefore seem to be the proper function of National Authority, whether central or local, in the education of the people; what is the limit of its obligations; what is the part of education in which it can lead the way; what is the region in which more powerful influences are at work, and in which it must take care not to hinder their operation; and what are the dangers to real education inseparable from a general national system. I shall avoid questions of the division of functions between central and local authorities, beset with so many bitter controversies, which are political rather than educational.

In the first place, so far as the mass of the youth of a country is concerned, the public instructor can only play a secondary part in the most important part of the education of the young—the development of character. The character of a people is by far its most important attribute. It has a great deal more moment in the affairs of the world, and is a much more vital factor in the promotion of national power and influence, and in the spread of Empire, than either physical or mental endowments. The character of each generation depends in the main upon the character of the generation which precedes it; of other causes in operation the effect is comparatively small. A generation may be a little better or a little worse than its forefathers, but it cannot materially differ from them. Improvement and degeneracy are alike slow. The chief causes which produce formation of character are met with in the homes of the people. They are of great variety and mostly too subtle to be controlled. Religious belief, ideas, ineradicable often in maturer life, imbibed from the early instruction of parents, the principles of morality current amongst brothers and sisters and playmates, popular superstitions, national and local prejudices, have a far deeper and more permanent effect upon character than the instruction given in schools

* Address of the president of the Educational Science Section of the British Association for the Advancement of Science. Glasgow, 1901.

or colleges. The teacher, it is true, exercises his influence among the rest. Men and women of all sorts, from university professors to village dames, have stamped some part of their own character upon a large proportion of their disciples. But this is a power that must grow feebler as the number of scholars is increased. In the enormous schools and classes in which the public instruction of the greater part of the children of the people is given, the influence on character of the individual teacher is reduced to a minimum. The old village dame might teach her half-dozen children to be kind and brave and to speak the truth, even if she failed to teach them to read and write. The headmaster of a school of 2,000 or the teacher of a class of eighty may be an incomparably better intellectual instructor, but it is impossible for him to exercise much individual influence over the great mass of his scholars.

There are, however, certain children for the formation of whose characters the nation is directly responsible—deserted children, destitute orphans and children whose parents are criminals or paupers. It is the duty and interest of the nation to provide for the moral education of such children and to supply artificially the influences of individual care and love. The neglect of this obligation is as injurious to the public as to the children. Homes and schools are cheaper than prisons and workhouses. Such a practice as that of permitting dissolute pauper parents to remove their children from public control to spend the summer in vice and beggary at races and fairs, to be returned in the autumn, corrupt in body and mind, to spread disease and vice amongst other children of the State, would not be tolerated in a community intelligently alive to its own interest.

A profound, though indirect and untraceable, influence upon the moral education of a people is exercised by all national administration and legislation. Everything which tends to make the existing generation wiser, happier or better has an indirect influence on the children. Better dwellings, unadulterated food, recreation grounds, temperance, sanitation, will all affect the character of the rising generation. Regulations for public instruction also influence character. A military spirit may be evoked by the kind of physical instruction given. Brutality may be developed by the sort of punishments enjoined or permitted. But all such causes have a comparatively slight effect upon national character, which is in the main the product for good or evil of more powerful causes which operate, not in the school, but in the home.

For the physical and mental development of children it is now admitted to be the interest and duty of a nation in its collective capacity to see that proper schools are provided in which a certain minimum of primary instruction should be free and compulsory for all, and, further, secondary instruction should be available for those fitted to

profit by it. But there are differences of opinion as to the age at which primary instruction should begin and end; as to the subjects it should embrace; as to the qualifications which should entitle to further secondary instruction; and as to how far this should be free or how far paid for by the scholar or his parents.

The age at which school attendance should begin and end is in most countries determined by economic rather than educational considerations. Somebody must take charge of infants in order that mothers may be at leisure to work; the demand for child labor empties schools for older children. In the United Kingdom minding babies of three years old and upwards has become a national function. But the infant 'school,' as it is called, should be conducted as a nursery, not as a place of learning. The chief employment of the children should be play. No strain should be put on either muscle or brain. They should be treated with patient kindness, not beaten with canes. It is in the school for older children, to which admission should not be until seven years of age, that the work of serious instruction should begin, and that at first for not more than two or three hours a day. There is no worse mistake than to attempt by too early pressure to cure the evil of too early emancipation from school. Beyond the mechanical accomplishments of reading, writing and ciphering, essential to any intellectual progress in after life, and dry facts of history and grammar, by which alone they are too often supplemented, it is for the interest of the community that other subjects should be taught. Some effort should be made to develop such faculties of mind and body as are latent in the scholars. The same system is not applicable to all; the school teaching should fit in with the life and surroundings of the child. Variety, not uniformity, should be the rule. Unfortunately the various methods by which children's minds and bodies can be encouraged to grow and expand are still imperfectly understood by many of those who direct or impart public instruction. Examinations are still too often regarded as the best instrument for promoting mental progress; and a large proportion of the children in schools, both elementary and secondary, are not really educated at all—they are only prepared for examinations. The delicately expanding intellect is crammed with ill-understood and ill-digested facts, because it is the best way of preparing the scholar to undergo an examination test. Learning to be used for gaining marks is stored in the mind by a mechanical effort of memory, and is forgotten as soon as the class-list is published. Intellectual faculties of much greater importance than knowledge, however extensive—as useful to the child whose schooling will cease at fourteen as to the child for whom elementary instruction is but the first step in the ladder of learning—are almost wholly neglected.

The power of research—the art of acquiring information for

oneself—on which the most advanced science depends, may by a proper system be cultivated in the youngest scholar of the most elementary school. Curiosity and the desire to find out the reason of things is a natural, and to the ignorant an inconvenient, propensity of almost every child; and there lies before the instructor the whole realm of nature knowledge in which this propensity can be cultivated. If children in village schools spent less of their early youth in learning mechanically to read, write and cipher, and more in searching hedgerows and ditch-bottoms for flowers, insects, or other natural objects, their intelligence would be developed by active research, and they would better learn to read, write and cipher in the end. The faculty of finding out things for oneself is one of the most valuable with which a child can be endowed. There is hardly a calling or business in life in which it is not better to know how to search out information than to possess it already stored. Everything, moreover, which is discovered sticks in the memory and becomes a more secure possession for life than facts lazily imbibed from books and lectures. The faculty of turning to practical uses knowledge possessed might be more cultivated in primary schools. It can to a limited extent, but to a limited extent only, be tested by examination. Essays, compositions, problems in mathematics and science, call forth the power of using acquired knowledge. Mere acquisition of knowledge does not necessarily confer the power to make use of it. In actual life a very scanty store of knowledge, coupled with the capacity to apply it adroitly, is of more value than boundless information which the possessor cannot turn to practical use. Some measures should be taken to cultivate taste in primary schools. Children are keen admirers. They can be early taught to look for and appreciate what is beautiful in drawing and painting, in poetry and music, in nature, and in life and character. The effect of such learning on manners has been observed from remote antiquity.

Physical exercises are a proper subject for primary schools, especially in the artificial life led by children in great cities: both those which develop chests and limbs, atrophied by impure air and the want of healthy games, and those which discipline the hand and the eye—the latter to perceive and appreciate more of what is seen, the former to obey more readily and exactly the impulses of the will. Advantage should be taken of the fact that the children come daily under the observation of a quasi-public officer—the school teacher—to secure them protection, to which they are already entitled by law, against hunger, nakedness, dirt, over-work, and other kinds of cruelty and neglect. Children's ailments and diseases should by periodic inspection be detected: the milder ones, such as sores and chilblains, treated on the spot, the more serious removed to the care of parents or hospitals. Diseases of the eye and all maladies that would impair the capacity of

a child to earn its living should in the interest of the community receive prompt attention and the most skilful treatment available. Special schools for children who are crippled, blind, deaf, feeble-minded or otherwise afflicted should be provided at the public cost, from motives, not of mere philanthropy, but of enlightened self-interest. So far as they improve the capacity of such children they lighten the burden on the community.

I make no apology for having dwelt thus long upon the necessity of a sound system of primary instruction: that is the only foundation upon which a national system of advanced education can be built. Without it our efforts and our money will be thrown away. But while primary instruction should be provided for, and even enforced upon, all, advanced instruction is for the few. It is the interest of the commonwealth at large that every boy and girl showing capacities above the average should be caught and given the best opportunities for developing those capacities. It is not its interest to scatter broadcast a huge system of higher instruction for any one who chooses to take advantage of it, however unfit to receive it. Such a course is a waste of public resources. The broadcast education is necessarily of an inferior character, as the expenditure which public opinion will at present sanction is only sufficient to provide education of a really high calibre for those whose ultimate attainments will repay the nation for its outlay on their instruction. It is essential that these few should not belong to one class or caste, but should be selected from the mass of the people, and be really the intellectual *élite* of the rising generation. It must, however, be confessed that the arrangements for selecting these choice scholars to whom it is remunerative for the community to give advanced instruction are most imperfect. No 'capacity-catching machine' has been invented which does not perform its function most imperfectly: it lets go some it ought to keep, and it keeps some it ought to let go. Competitive examination, besides spoiling more or less the education of all the competitors, fails to pick out those capable of the greatest development. It is the smartest, who are also sometimes the shallowest, who succeed. 'Whoever thinks in an examination,' an eminent Cambridge tutor used to say, 'is lost.' Nor is position in class obtained by early progress in learning an infallible guide. The dunce of the school sometimes becomes the profound thinker of later life. Some of the most brilliant geniuses in art and science have only developed in manhood. They would never in their boyhood have gained a county scholarship in a competitive examination.

In primary schools, while minor varieties are admissible, those, for instance, between town and country, the public instruction provided is mainly of one type; but any useful scheme of higher education

must embrace a great variety of methods and courses of instruction. There are roughly at the outset two main divisions of higher education—the one directed to the pursuit of knowledge for its own sake, of which the practical result cannot yet be foreseen, whereby the 'scholar' and the votary of pure science is evolved; the other directed to the acquisition and application of special knowledge by which the craftsman, the designer and the teacher are produced. The former of these is called secondary, the latter technical, education. Both have numerous subdivisions which trend in special directions.

The varieties of secondary education in the former of these main divisions would have to be determined generally by considerations of age. There must be different courses of study for those whose education is to terminate at sixteen, at eighteen and at twenty-two or twenty-three. Within each of these divisions, also, there would be at least two types of instruction, mainly according as the student devoted himself chiefly to literature and language, or to mathematics and science. But a general characteristic of all secondary schools is that their express aim is much more individual than that of the primary school: it is to develop the potential capacity of each individual scholar to the highest point, rather than to give, as does the elementary school, much the same modicum to all. For these reasons it is essential to have small classes, a highly educated staff and methods of instruction very different from those of the primary school. In the formation of character the old secondary schools of Great Britain have held their own with any in the world. In the rapid development of new secondary schools in our cities it is most desirable that this great tradition of British public school life should be introduced and maintained. It is not unscientific to conclude that the special gift of colonizing and administering dependencies, so characteristic of the people of the United Kingdom, is the result of that system of self-government to which every boy in our higher public schools is early initiated. But while we boast of the excellence of our higher schools on the character-forming side of their work, we must frankly admit that there is room for improvement on their intellectual side. Classics and mathematics have engrossed too large a share of attention; science, as part of a general liberal education, has been but recently admitted, and is still imperfectly estimated. Too little time is devoted to it as a school subject; its investigations and its results are misunderstood and undervalued. Tradition in most schools, nearly always literary, alters slowly, and the revolutionary methods of science find all the prejudices of antiquity arrayed against them. Even in scientific studies, lack of time and the obligation to prepare scholars to pass examinations cause too much attention to be paid to theory, and too little to practice, though it is by the latter that the power of original research and of

original application of acquired knowledge is best brought out. The acquisition of modern languages was in bygone generations almost entirely neglected. In many schools the time given to this subject is still inadequate, the method of teaching antiquated, the results unsatisfactory. But the absolute necessity of such knowledge in literature, in science and in commerce is already producing a most salutary reform.

The variety of types of secondary instruction demanded by the various needs and prospects of scholars requires a corresponding variety in the provision of schools. This cannot be settled by a rule-of-three method, as is done in the case of primary instruction. We cannot say that such and such an area being of such a size and of such a population requires so many secondary schools of such a capacity. Account must be taken in every place of the respective demands for respective types and grades of secondary education; and existing provision must be considered.

It must not, however, be forgotten that a national system of education has its drawbacks as well as its advantages. The most fatal danger is the tendency of public instruction to suppress or absorb all other agencies, however long established, however excellent their work, and to substitute one uniform mechanical system, destructive alike to present life and future progress. In our country, where there are public schools of the highest repute carried on for the most part under ancient endowments, private schools of individuals and associations, and universities entirely independent of the Government, there is reasonable hope that with proper care this peril may be escaped. But its existence should never be forgotten. Universal efficiency in all establishments that profess to educate any section of the people may properly be required; but the variety, the individuality and the independence of schools of every sort, primary and secondary, higher and lower, should be jealously guarded. Such attributes once lost can never be restored.

There still remains for our consideration the second division of higher education, viz., the applied or technological side. It is in this branch of education that Great Britain is most behind the rest of the world; and the nation in its efforts to make up the lost ground fails to recognize the fact that real technical instruction (of whatever type) cannot possibly be assimilated by a student unless a proper foundation has been laid previously by a thorough grounding of elementary and secondary instruction. Our efforts at reform are abrupt and disconnected. A panic from time to time sets in as to our backwardness in some particular branch of commerce or industry. There is a sudden rush to supply the need. Classes and schools spring up like mushrooms, which profess to give instruction in the lacking branch of applied

science to scholars who have no elementary knowledge of the particular science, and whose general capacities have never been sufficiently developed. Students are invited to climb the higher rungs of the ladder of learning who have never trod the lower. But science cannot be taught to those who cannot read, nor commerce to those who cannot write. A few elementary lessons in shorthand and bookkeeping will not fit the British people to compete with the commercial enterprise of Germany. Such sudden and random attempts to reform our system of technical education are time and money wasted. There are grades and types in technological instruction, and progress can only be slow. It is useless to accept in the higher branches a student who does not come with a solid foundation on which to build. In such institutions as the Polytechnics at Zurich and Charlottenburg we find the students exclusively drawn from those who have already completed the highest branches of general education; in this country there is hardly a single institution where this could be said of more than a mere fraction of its students. The middle grades of technological instruction suffer from a similar defect. Boys are entered at technical institutions whose only previous instruction has been at elementary schools and evening classes; whose intellectual faculties have not been developed to the requisite point; and who have to be retaught the elements to fit them for the higher instruction. In fact there is no scientific conception of what this kind of instruction is to accomplish and of its proper and necessary basis of general education.

Yet this is just the division of higher education in which public authority finds a field for its operations practically unoccupied. There are no ancient institutions which there is risk of supplanting. The variety of the subject itself is such that there is little danger of sinking into a uniform and mechanical system. What is required is first a scientific, well-thought-out plan and then its prompt and effective execution. A proper provision of the various grades and types of technological instruction should be organized in every place. The aim of each institution should be clear; and the intellectual equipment essential for admission to each should be laid down and enforced. The principles of true economy, from the national point of view, must not be lost sight of. Provision can only be made (since it must be of the highest type to be of the slightest use) for those really qualified to profit by it to the point of benefiting the community. Evening classes with no standard for admission and no test of efficiency may be valuable from a social point of view as providing innocent occupation and amusement, but they are doing little to raise the technical capacity of the nation. So far from 'developing a popular demand for higher instruction' they may be preventing its proper growth by perpetuating the popular misconception of what real technical instruction is, and

of the sacrifices we must make if our people are to compete on equal terms with other nations in the commerce of the world. The progress made under such a system would at first be slow; the number of students would be few until improvements in our systems of primary and secondary instruction afforded more abundant material on which to work; but our foundation would be on a rock, and every addition we were able to make would be permanent, and contribute to the final completion of the edifice.

It is the special function of the British Association to inculcate 'a scientific view of things' in every department of life. There is nothing in which scientific conception is at the present moment more urgently required than in national education; and there is this peculiar difficulty in the problem, that any attempt to construct a national system inevitably arouses burning controversies, economical, religious and political. It is only a society like this, with an established philosophical character, that can afford to reduce popular cries about education (which ignore what education really is, and perpetuate the absurdity that it consists in attending classes, passing examinations and obtaining certificates) to their true proportions. If this Association could succeed in establishing in the minds of the people a scientific conception of a national education system, such as has already been evolved by most of the nations of Europe, the States of America, and our own colonies, it would have rendered a service of inestimable value to the British nation.

THE EVOLUTION OF THE HUMAN INTELLECT.

By Professor EDWARD L. THORNDIKE,
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TO the intelligent man with an interest in human nature it must often appear strange that so much of the energy of the scientific world has been spent on the study of the body and so little on the study of the mind. 'The greatest thing in man is mind,' he might say, 'yet the least studied.' Especially remarkable seems the rarity of efforts to trace the evolution of the human intellect from that of the lower animals. Since Darwin's discovery, the beasts of the field, the fowl of the air and the fish of the sea have been examined with infinite pains by hundreds of workers in the effort to trace our physical genealogy, and with consummate success; yet few and far between have been the efforts to find the origins of intellect and trace its progress up to human faculty. And none of them has achieved any secure success.

It may be premature to try again, but a somewhat extended series of studies of the intelligent behavior of fishes, reptiles, birds and mammals, including the monkeys, which it has been my lot to carry out during the last five years, has brought results which seem to throw light on the problem and to suggest its solution.

Experiments have been made on fishes, reptiles, birds and various mammals, notably dogs, cats, mice and monkeys, to see how they learned to do certain simple things in order to get food. All these animals manifest fundamentally the same sort of intellectual life. Their learning is after the same general type. What that type is can be seen best from a concrete instance. A monkey was kept in a large cage. Into the cage was put a box, the door of which was held closed by a wire fastened to a nail which was inserted in a hole in the top of the box. If the nail was pulled up out of the hole the door could be pulled open. In this box was a piece of banana. The monkey, attracted by the new object, came down from the top of the cage and fussed over the box. He pulled at the wire, at the door and at the bars in the front of the box. He pushed the box about and tipped it up and down. He played with the nail and finally pulled it out. When he happened to pull the door again it of course opened. He reached in and got the food inside. It had taken him 36 minutes to get in. Another piece of food being put in and the door closed the occurrences of the first trial were repeated, but there was less of the profitless pulling and tipping. He got in this time in 2 minutes and 20 seconds. With repeated trials

the animal finally came to drop entirely the profitless acts and to take the nail out and open the door as soon as the box was put in his cage. He had, we should say, learned to get in.

The process involved in the learning was evidently a process of selection. The animal is confronted by a state of affairs or, as we may call it, a 'situation.' He reacts in the way that he is moved by his innate nature or previous training to do, by a number of acts. These acts include the particular act that is appropriate and he succeeds. In later trials the impulse to this one act is more and more stamped in, this one act is more and more associated with that situation, is selected from amongst the others by reason of the pleasure it brings the animal. The profitless acts are stamped out; the impulses to perform them in that situation are weakened by reason of the positive discomfort or the absence of pleasure resulting from them. So the animal finally performs in that situation only the fitting act.

Here we have the simplest and at the same time the most widespread sort of intellect or learning in the world. There is no reasoning, no process of inference or comparison; there is no thinking about things, no putting two and two together; there are no ideas—the animal does not think of the box or of the food or of the act he is to perform. He simply comes after the learning to feel like doing a certain thing under certain circumstances which before the learning he did not feel like doing. Human beings are accustomed to think of intellect as the power of having and controlling ideas and of ability to learn as synonymous with ability to have ideas. But learning by having ideas is really one of the rare and isolated events in nature. There may be a few scattered ideas possessed by the higher animals, but the common form of intelligence with them, their habitual method of learning, is not by the acquisition of ideas, but by the selection of impulses.

Indeed this same type of learning is found in man. When we learn to drive or play tennis or billiards, when we learn to tell the price of tea by tasting it or to strike a certain note exactly with the voice, we do not learn in the main by virtue of any ideas that are explained to us, by any inferences that we reason out. We learn by the gradual selection of the appropriate act or judgment, by its association with the circumstances or situation requiring it in just the way that the animals do.

From the lowest animals of which we can affirm intelligence up to man this type of intellect is found. With it there are in the mammals obscure traces of the ideas which come in the mental life of man to outweigh and hide it. But it is the basal fact. As we follow the development of animals in time we find the capacity to select impulses growing. We find the associations thus made between situation and act growing in number, being formed more quickly, lasting longer and

becoming more complex and more delicate. The fish can learn to go to certain places, to take certain paths, to bite at certain things and refuse others, but not much more. It is an arduous proceeding for him to learn to get out of a small pen by swimming up through a hole in a screen. The monkey can learn to do all sorts of things. It is a comparatively short and easy task for him to learn to get into a box by unhooking a hook, pushing a bar around and pulling out a plug. He learns quickly to climb down to a certain place when he sees a letter T on a card and to stay still when he sees a K. He performs the proper acts nearly as well after 50 days as he did when they were fresh in his mind.

This growth in the number, speed of formation, permanence, delicacy and complexity of associations possible for an animal reaches its acme in the case of man. Even if we leave out of question the power of reasoning, the possession of a multitude of ideas and abstractions and the power of control over impulses, purposive action, man is still the intellectual leader of the animal kingdom by virtue of the superior development in him of the power of forming associations between situations or sense impressions and acts, by virtue of the degree to which the mere learning by selection possessed by all intelligent animals has advanced. In man the type of intellect common to the animal kingdom finds its fullest development, and with it is combined the hitherto non-existent power of thinking about things and rationally directing action in accord with thought.

Indeed it may be that this very reason, self-consciousness and self-control which seem to sever human intellect so sharply from that of all other animals are really but secondary results of the tremendous increase in the number, delicacy and complexity of associations which the human animal can form. It may be that the evolution of intellect has no breaks, that its progress is continuous from its first appearance to its present condition in adult civilized human beings. If we could prove that what we call ideational life and reasoning were not new and unexplainable species of intellectual life but only the natural consequences of an increase in the number, delicacy and complexity of associations of the general animal sort, we should have made out an evolution of mind comparable to the evolution of living forms.

In 1890 William James wrote, "The more sincerely one seeks to trace the actual course of psycho-genesis, the steps by which as a race we may have come by the peculiar mental attributes which we possess, the more clearly one perceives 'the slowly gathering twilight close in utter dark.'" Can we perhaps prove him a false prophet? Let us first see if there be any evidence that makes it probable that in some way or another the mere extension of the animal type of intellect has produced the human sort. If we do let us proceed to seek a possible

account of *how* this might have happened, and finally to examine any evidence that shows this possible 'how' to have been the real way in which human reason has evolved.

It has already been shown that in the animal kingdom there is, as we pass from the early vertebrates down to man, a progress in the evolution of the general associative process which practically equals animal intellect, that this progress continues as we pass from the monkeys to man. Such a progress is a real fact; it does exist as a possible *vera causa;* it is thus at all events better than some imaginary cause of the origin of human intellect, the very existence of which is in doubt. In a similar manner we know that the cell structures which compose the brain and the connections between which are the physiological parallel of the associations animals form show as we pass down through the vertebrate series an evolution along lines of increased delicacy and complexity. That an animal associates a certain act with a certain felt situation means that he forms or strengthens connections between certain cells. The increase in the number, delicacy and complexity of cell structures is thus the basis for an increase in the number, delicacy and complexity of associations. Now the evolution noted in cell structures affects man as well as the other vertebrates. He stands at the head of the scale in that respect as well. May not this obvious supremacy in the animal type of intellect and in the adaptation of his brain to it be at the bottom of his supremacy in being the sole possessor of reasoning?

This question becomes more pressing if we realize that we must have some sort of brain correlate for ideational life and reasoning. Some sort of difference in processes in the brain must be at the basis of the mental differences between man and the lower animals, we should all admit. And it would seem wise to look for that difference amongst differences which really do or at least may exist. Now the most likely brain difference between man and the lower animals for our purpose, to my mind indeed the only likely one, is just this difference in the fineness of organization of the cell structures. If we could show with any degree of probability how it might account for the presence of ideas and of reasoning we should at least have the satisfaction of dealing with a cause actually known to exist.

The next important fact is that the intellect of the infant six months to a year old is of the animal sort, that ideational and reasoning life is not present in his case, that the only obvious intellectual difference between him and a monkey is in the quantity and quality of the associations formed. In the evolution of the infant's mind to its adult condition we have the actual transition within an individual from the animal to the human type of intellect. If we look at the infant and ask what is in him to make in the future a thinker and

reasoner, we must answer either by invoking some mysterious capacity, the presence of which we cannot demonstrate, or by taking the difference we actually do find. That is the difference in the quality and quantity of associations of the animal sort. Even if we could never see how it came to cause the future intellectual life, it would seem wiser to believe that it did than to resort to faith in mysteries. Surely there is enough evidence to make it worth while to ask our second question, 'How might this difference cause the life of ideas and reasoning?'

To answer this question fully would involve a most intricate treatment of the whole intellectual life of man, a treatment which cannot be attempted without reliance on technical terms and psychological formulas. A fairly comprehensible account of the general features of such an answer can however be given. The essential thing about the thinking of the animals is that they feel things in gross. The kitten that learned to respond differently to the signals 'I must feed those cats' and 'I will not feed them,' felt each signal as a vague total including the tone, the movements of my head, etc. It did not have an idea of the sound of *I,* another of the sound of *must,* another of the sound of *feed,* etc. It did not turn the complex impression into a lot of elements, but felt it, as I have said, in gross. The dog that learned to get out of a box by pulling a loop of wire did not feel the parts of the box separately, the loop as a definite circle of a certain size, did not feel his act as a sum of certain particular movements. The monkey that learned to know the letter K from the letter Y did not feel the separate lines of the letter, have definite ideas of the parts. He just felt one way when he saw one total impression and another way when he saw another.

Strictly human thinking on the contrary has for its essential characteristic the breaking up of gross total situations into a number of particular feelings. When in the presence of ten jumping tigers, we not only feel like running, but also feel the number of the tigers, their color, their size, etc. When instead of merely associating some act with some situation in the animal way, we think the situation out, we have a number of particular feelings of its elements. In some cases it is true we remain restricted to the animal sort of feelings. The sense impressions of suffocation, of the feeling of a new style of clothes, of the pressure of 10 feet of water above us, of malaise, of nausea and such like, remain for most of us vague total feelings to which we react and which we feel most acutely, but which do not take the form of definite ideas that we can isolate or combine or compare. Such feelings we say are not parts of our real intellectual life. They *are* parts of our intellectual life if we mean by it the mental life concerned in learning, but they are not if we mean by it the life of reasoning.

Can we now see how the vague gross feelings of the animal sort might turn into the well-defined particular ideas of the human sort, by the aid of a multitude of delicate associations?

It seems to be a general law of mind that any mental element which occurs with a number of different mental elements, appears that is in a number of different combinations, tends to thereby acquire an independent life of its own. We show children six lines, six dots, six peas, six pieces of paper, etc., and thus create the definite feeling of sixness. Out of the gross feelings of a certain number of lines, of dots, etc., we evolve the definite elementary feeling of sixness by making the 'six' aspect of the situations appear in a number of different connections. We learn to feel whiteness as a definite idea by seeing white paper, white cloth, white eggs, white plates, etc., etc. We learn to feel the meaning of *but* or *in* or *notwithstanding* by feeling the meaning of a number of total phrases containing each of them. Now in this general law by which different associates for the same elementary process elevate it out of its position as an undifferentiated fragment of a gross total feeling, we have, I think, the manner in which the vague feelings of the nine-months-old infant become the definite ideas of the five-year-old boy, the manner in which in the race the animal mind has evolved into the human, and the explanation of the service performed by the increase in the delicacy of structure of the human brain and the consequent increase in the number of associations.

The bottle to the six-months-old infant is a vague sense impression which the infant does not think about or indeed in the common meanings of the words perceive or remember or imagine. Its presence does not arouse ideas, but action. It is not to him a thing so big, or so shaped, or so heavy, but is just a vaguely sizable thing to be reached for, grabbed and sucked. Like the lower animals, with the exception that as he grows a little older he reacts in very many more ways, the child feels things in gross in a way to lead to direct reactions. Vague sense impressions and impulses make up his mental life. The bottle, which to a dog would be a thing to smell at and paw, to a kitten a thing to smell at and perhaps worry, is to the child a little later a thing to grab and suck and turn over and drop and pick up and pull at and finger and rub against its toes and so on. The sight of the bottle thus becomes associated with a lot of different reactions, and thus by our general law tends to gain a position independent of any of them, to evolve from the condition of being a portion of the cycles see-grab, see-drop, see-turn over, etc., to the condition of being a definite idea.

The increased delicacy and complexity of the cell structures in the human brain gives the possibility of very small parts of the brain processes forming different connections, allows the brain to work in

very great detail, provides processes ready to be turned into definite ideas. The great number of associations which the human being forms furnish the means by which this last event is consummated. The infant's vague feelings of total situations are by virtue of the detailed working of his brain all ready to split up into parts, and his general activity and curiosity provide the multitude of different connections which allow them to do so. The dog on the other hand has few or no ideas because his brain acts in coarse fashion and because there are few connections with each single process.

When once the mind begins to function by having definite ideas all the phenomena of reasoning soon appear. The transition from one idea to another is the feeling of their relationship, of similarity or difference or whatever it may be. As soon as we find any words or other symbols to express such a feeling, or to express our idea of an action or condition, we have explicit judgments. Observation of any child will show us that the mind cannot rest in a condition where it has a large body of ideas without comparing them and thinking about them. The ideas carry within them the forces that make abstractions, feelings of similarity, judgments and the other characteristics of reasoning.

In children two and three years of age we find all these elements of reasoning present and functioning. The product of children's reasoning is often irrational but the processes are all there. The following instances from a collection of children's sayings by Mr. H. W. Brown show children making inductions and deductions after the same general fashion as adults:

(2 yrs.) T. pulled the hairs on his father's wrist. Father. "Don't T., you hurt papa!" T. "It didn't hurt grandpa."

(2 yrs. 5 mos.) M. said, "Gracie can't walk, she wears little bits of shoes; if she had mine she could walk. When I get some new ones, I'm going to give her these, so she can walk."

(3 yrs.) W. likes to play with oil paints. Two days ago my father told W. he must not touch the paints any more, for he was too small. This morning W. said, "When my papa is a very old man, and when I am a big man and don't need any papa, then I can paint, can't I, mamma?"

(3 yrs.) G.'s aunt gave him ten cents. G. went out, but soon came back saying, "Mamma, we will be rich now." "Why so, G?" "Because I planted my ten cents, and we will have lots of ten cents growing."

(3 yrs.) B. climbed up into a large express wagon, and would not get out. I helped him out, and it was not a minute before he was back in the wagon. I said, "B., how are you going to get out of there now?" He replied, "I can stay here till it gets little, and then I can get out my own self."

(3 yrs.) F. is not allowed to go to the table to eat unless she has her face and hands washed and her hair combed. The other day she went to a lady visiting at her house and said, "Please wash my face and hands and comb my hair; I am very hungry."

(3 yrs.) If C. is told not to touch a certain thing, that it will bite him,

he always asks if it has a mouth. The other day he was examining a plant, to see if it had a mouth. He was told not to break it, and he said, "Oh, it won't bite, because I can't find any mouth."

Nowhere in the animal kingdom do we find the psychological elements of reasoning save where there is a mental life made up of the definite feelings which I have called 'ideas,' but they spring up like magic as soon as we get in a child a body of such ideas. If we have traced satisfactorily the evolution of a life of ideas from the animal life of vague sense impressions and impulses we may be reasonably sure that no difficulty awaits us in following the life of ideas in its course from the chaotic dream of early childhood to the logical world-view of the adult scientist.

In a very short time we have come a long way, from the simple learning of the minnow or chick to the science and logic of man. The general frame of mind which one acquires from the study of animal behavior and of the mental development of young children makes our hypothesis seem vital and probable. If the facts did eventually corroborate it we should have an eminently simple genesis of human faculty, for we could put together the gist of our contention in a few words. We should say:

"The function of intellect is to provide a means of modifying our reactions to the circumstances of life so that we may secure pleasure, the symptom of welfare. Its general law is that when in a certain situation an animal acts so that pleasure results, that act is selected from all those performed and associated with that situation so that when the situation recurs the act will be more likely to follow than it was before, that on the contrary the acts which when performed in a certain situation have brought discomfort tend to be dissociated from that situation. The intellectual evolution of the race consists in an increase in the number, delicacy, complexity, permanence and speed of formation of such associations. In man this increase reaches such a point that an apparently new type of mind results, which conceals the real continuity of the process. This mental evolution parallels the evolution of the cell structures of the brain from fewer and simpler and grosser to many and complex and delicate."

Nowhere more truly than in his mental capacities is man a part of nature. His instincts, that is his inborn tendencies to feel and act in certain ways, show throughout marks of kinship with the lower animals, especially with our nearest relatives physically, the monkeys. His sense powers show no new creation. His intellect we have seen to be a simple though extended variation from the general animal sort. This again is presaged by the similar variation in the case of the monkeys. Amongst the minds of animals that of man leads, not as a demigod from another planet, but as a king from the same race.

THE ORIGIN OF SEX IN PLANTS.

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ZOOLOGISTS have held various views as to the origin of sex in animals, but the subject is confessedly speculative. They have very little data bearing upon the problem—the gap between the Protozoa and the Metazoa is so immense and characterized by such a paucity of intermediate types. We pass directly from relatively simple conjugation among unicellular forms to the complicated conditions in higher animals, where the sexual elements have reached a very high state of specialization.

Botany is very much more fortunate in this respect. It is not difficult to understand the evolution of multicellular plants from the unicellular, and we have a great deal of evidence that bears on the origin and differentiation of sex. Greater interest is added to this subject because we have reason to believe that sex has arisen in a number of divergent groups by identical processes but without relation to one another, so that similar complex results have been worked out independently.

We shall deal entirely with that large group of the lower plants known as the algae which includes all the plants below the liverworts and mosses with the exception of the fungi. One need study the algæ but slightly to realize that they are a very diverse assemblage of forms comprising many lines of ascent, some of which are marked out clearly, but many of them mere fragments and remnants of former series that have been broken up by the extinction of ancestral types.

There are certain groups of algae well known to all students of botany that have no place in the present discussion. Such for example are the Conjugales comprising types such as Spirogyra, Zygnema, the desmids, and again, the diatoms. However valuable these forms may be for certain laboratory studies, they should never be cited as typical illustrations of sexual processes among the lower plants. They are rather extraordinarily specialized groups and have developed peculiarities of a high order. Again, there are numbers of groups complex in their organization, whose relationship to other forms is so remote that we must place them quite apart by themselves. Such for example are the stoneworts (Charales), the red algae (Rhodophyceae) and some

forms of the brown algae (Phaeophyceae). These groups give us no data on the problems that we are to consider.

There is left for us a numerous and varied array of algae, representing several lines of ascent, all tending to diverge from one another. But these forms have some important points in common, particularly as concerns certain events in their life histories. There is immense variety in the form of the plant body which ranges from a single cell to structures with stalks and leaf-like organs. There are likewise exhibited many degrees of sexual development, from a few forms which actually appear to illustrate the dawning of sex through various intermediate stages to many types in which the sexual elements have become highly specialized. The story of the differentiation of sex, that is, the evolution of the egg and sperm from the primitive sexual elements, is most interesting, but would require extended treatment. It must be left for some future paper. Our problem is to understand how the primitive sexual elements arose.

Almost all the algae in the groups referred to in the paragraph above have one phase in their life histories in common. They usually present a period, although sometimes very short, when the protoplasm of the cells is in the form of free-swimming elements. These are called zoospores or swarm-spores and they are commonly little pear-shaped bodies, the pointed ends bearing 2 or perhaps 4 delicate hair-like organs, called cilia, whose vibrations give the zoospores their rapid movement. A glance at the illustrations will show the form of these motile cells.

Zoospores are likely to be produced in greatest quantity at certain seasons or under particular conditions of light or temperature, and their purpose is plainly the rapid propagation of the species. But there is a deep significance in their general conformity to a certain type of structure and their almost universal presence in the groups that we are considering. In a certain sense the zoospore represents a return on the part of these algae to primitive ancestral conditions.

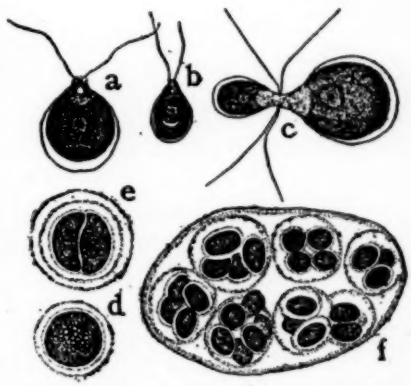

FIG. 1. STAGES IN THE LIFE HISTORY OF CHLAMYDOMONAS. *a*, VEGETATIVE CELL. *b*, SMALL GAMETE. *c*, CONJUGATION OF GAMETES. *d*, SEXUALLY FORMED SPORE. *e*, FIRST DIVISION OF SPORE. *f*, QUIESCENT CONDITION, CELLS MULTIPLYING BY DIVISION. (AFTER GOROSCHANKIN.)

There are many unicellular algae that pass a large part, perhaps the greater part, of their lives as motile cells with a structure essentially the same as

zoospores. These lowly types of the Protococcales are certainly most nearly related to the parent forms of all the higher algae. The principal stages in the life history of such a type (Chlamydomonas) are illustrated in Figure 1. The free-swimming cell is shown in *a* and *b*. In *c* we have the conjugation of two individuals which gives a sexually formed spore such as appears in *d*. *e* and *f* present a quiescent condition when the cells multiply for a short time by fission.

The evolution of the algae has led for the most part to the development and long continuance of such phases of the life history as are stationary, and from these the filamentous, membranous and otherwise differentiated plant bodies have arisen. Finally the motile stage became so shortened as to be only a method of reproduction on the part of the plant and is passed over very quickly.

The zoospore then takes on new interest when one contemplates its relation to the past, realizing that it represents conditions of a remote period when the algae were much simpler than they are now and passed the greater part of their lives in a motile condition. It is not likely that the first algal types were motile, for the lowest group of all, the Cyanophyceae or blue-green algae, presents forms whose cells are always stationary, reproducing by simple fission.

But above the lower stretches of the algae, the zoospore appears with great regularity and usually conspicuously in the life history. There are certain types (unicellular Volvocaceae), whose life histories are mostly or entirely alternations of motile conditions and quiescent states when the cells come to rest, lose their cilia and remain motionless for many days. Such resting cells are well known to students of the lower algae, and it is an interesting fact that they may pass quickly and readily back to the motile form. Indeed there is every reason to believe that the one state or the other is largely determined by the physical environment of the organism. Recent studies by Livingston have shown for one type (Stigeoclonium) that zoospores immediately follow the transfer of cells in a resting condition from a certain solution of salts to a weaker solution, and this is an excellent illustration of the sort of factors that influence the alga.

In our discussion of the problem of the origin of sex we are to deal chiefly with forms whose motile conditions are so shortened as to be manifestly largely or wholly reproductive in their purposes. The plants are stationary, but at times and under certain conditions zoospores are produced in great numbers. These, after a brief existence as free-swimming cells, settle down and give rise to a new stationary plant body usually like the parent.

Zoospores or swarm spores are wonderfully alike in structure in the algae that are most closely related to one another. The prevailing type among the green algae (Chlorophyceae) is a pear-shaped cell with 2

or frequently 4 cilia at the pointed end. The illustrations show these and other characters clearly. A portion of the protoplasm is differentiated as a green body (chloroplast), which only partially fills the rounded end of the zoospore, leaving the rest of the cell quite clear. Sometimes the chloroplast contains a central body called the pyrenoid, which is associated with the starch-forming activities of the chloroplast. This structure must not be confused with the nucleus of the cell, the latter being almost always invisible in the living zoospore. Finally, one may always expect to find in the colorless pointed end, near the cilia, a small bright red body called the pigment spot. The pigment spot is generally believed to have a relation to the sensitiveness displayed by zoospores towards light, not in any sense, however, as an organ of vision, as might be judged by the unfortunate term 'eye-spot' that is sometimes applied to it.

Such is the structure of the zoospores. Now let us consider their habits. As we have said before, several are likely to be developed in a single cell, but there is no rule as to number. Sometimes the entire contents of a cell will slip out as a single zoospore, but more frequently 8, 16 or 32 will be formed, a variable number even in the same plant, and in certain cases the parent cell will give rise to hundreds. The zoospores escape from the mother cell or sporange usually through some opening in the wall and immediately swim off. They may be developed so numerously that the water is actually colored greenish and the field of the microscope shows hundreds of these organisms moving rapidly in various directions. Such appearances have given them the appropriate name of swarm-spores. The swarming of zoospores is best shown under certain conditions of illumination. The zoospores are very sensitive to light and usually arrange themselves with reference to its source so that the long axes are parallel with the incoming rays. If a vessel of water be placed so that the light rays come from one direction, as from a window, the zoospores will move in parallel lines towards or away from the source of the illumination. They will thus collect in clouds in various parts of the vessel, the exact position being somewhat modified by the currents of water that slowly circulate through every brightly illuminated vessel.

Generally speaking the swarm-spores that one is most likely to see will be asexual. Their activities cease after a few hours or perhaps minutes and they then attach themselves in some suitable position, germinate and develop young plants called sporelings. Sporelings of the alga, Ulothrix, are shown in Figure 2, *d*, they having developed from a zoospore like *c*.

But frequently and under conditions that have been in part determined swarm-spores will behave quite differently. They will swim at first very actively, approaching one another and then darting away,

but finally gathering in small groups and sorting themselves in pairs. The elements in such a pair begin to fuse together; the process is called conjugation and represents the simplest form of sexuality. The two sexual cells are called gametes, but they are nothing more than zoospores so constituted that they must fuse with one another in order to live.

The gametes show their relationship to zoospores in various ways and there is no doubt that they arose from the latter. In the first place they have the same general structure and are developed in the same sorts of cells on the mother plant. But the most important evidence of affinity is exhibited by certain gametes that are so much like zoospores that they will sometimes settle down and germinate without conjugation. This means that their sexual characters are not strongly enough developed to overcome the vegetative tendencies of their parents the asexual zoospores. However, the sporelings that come from these abortive or perhaps parthenogenetic gametes are weaker than the products of the ordinary or normal zoosopores and sometimes never reach full development. As may be guessed, this curious intermediate condition between the zoospore and gamete furnishes a most important clue to the fundamental distinctions that separate the one from the other. These differences are evidently physiological rather than morphological in character.

It is only recently that botanists have in part understood and attempted to define precisely the conditions that determine the development on the one hand of zoospores and on the other of gametes. In a general way it has been believed for a long time that the problem was a physiological one and that various environmental conditions of season, temperature or light were responsible for the results. But in the past ten years there have been numerous studies, on various types of the lower plants, attempting to establish as exactly as possible the chemical and physical factors at work. In this field of research the botanist, Klebs, has been especially active, and he, above all others, deserves the credit of developing certain experimental methods of attack. These have yielded important results and justify the belief that we may in the future obtain much precise knowledge.

Klebs treats the forms to as many well-defined conditions as he can devise, various as to the food, the osmotic properties of the water, the light and the temperature. The results have been very remarkable considering the difficulties of the problems. We can not do better than to follow his studies on one or two forms to illustrate the possibilities of investigations in this difficult field.

His studies on Ulothrix are interesting. This is a lowly type of unbranched filamentous alga common in both fresh and salt water. The zoospores (Figure 2, *b*) are formed in varying numbers, but usually

4 or 8 in a cell. They are relatively large structures with 4 cilia and have the appearance shown in Figure 2, *c*. These 4-ciliate zoospores are never sexual and they develop new Ulothrix filaments like their parent. This simple method of reproduction may be continued for

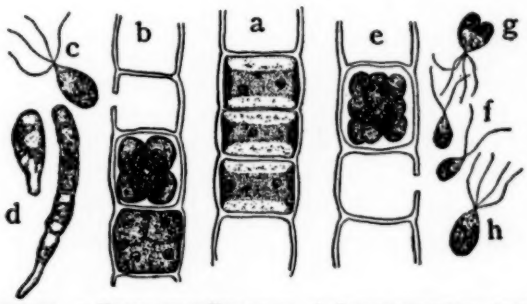

FIG. 2. ULOTHRIX. *a*, VEGETATIVE FILAMENT. *b*, DEVELOPMENT OF ASEXUAL ZOOSPORES. *c*, ZOOSPORE. *d*, SPORELINGS. *e*, CELL CONTAINING GAMETES. *f*, GAMETES. *g*, CONJUGATION OF GAMETES. *h*, SEXUALLY FORMED SPORE.

many months, but at times the conditions are such that another form of swarm-spore appears. These elements are much smaller than the usual zoospores, are developed more numerously in the mother cell and have 2 cilia as is shown in Figure 2, *e, f*. They are gametes and as a rule fuse readily with one another in pairs. The free-swimming gametes are shown in Figure 2, *f*, and two stages in the conjugation appear in *g* and *h*. If conjugation does not take place, the gametes settle down and in certain instances have been observed slowly germinating; but they develop feeble plants.

Now what are the causes that make the plant produce asexual zoospores on the one hand and gametes on the other? Are they deeply seated in the protoplasm of Ulothrix? In the first place there is no rule or rhythm in the appearance of zoospores or gametes, no time when conditions within the plant demand their development. And again, structurally, there is no hard and fast line between the zoospore and gamete; on the contrary, there are gradual transitions between these two forms of swarm spores. The problem thus resolves itself into an inquiry as to the precise environmental influences, the chemical and physical factors affecting the Ulothrix filament, whether they are actually able to make the plant form zoospores or not according to certain conditions. The habits of Ulothrix show us clearly that there are such factors, but the adjustments are so delicate that, apart from a very clear relation to temperature and the character of the salts in solution, it has not been possible to formulate them with exactness.

But other studies of Klebs, on forms that lend themselves more readily to cultivation than Ulothrix, have given some very definite results. Hydrodictyon, the water-net, is an alga that may be cultivated

with great ease in the laboratory. This plant is a great cell colony, involving usually thousands of elements which are joined to one another to form a net of polygonal meshes. A portion of such a plant is shown in Figure 3, *a*. These cells after they have reached a certain age produce zoospores that may be either asexual or sexual (gametes). The gametes are smaller and are produced much more numerously than

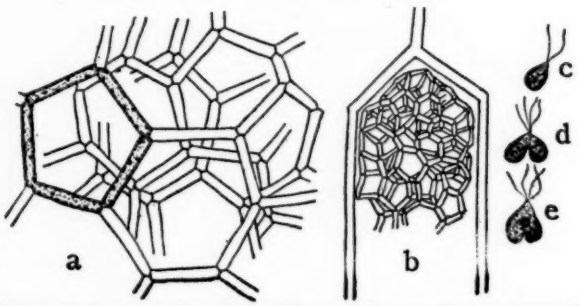

FIG. 3. HYDRODICTYON. *a*, PORTION OF NET. *b*, END OF CELL SHOWING YOUNG NET IN ITS INTERIOR. *c*, GAMETE. *d*, *e*, CONJUGATION OF GAMETES.

the asexual elements. They escape from the mother-cell and after swarming in the water conjugate in pairs (see Figure 3, *c*, *d*, *e*). The asexual swarm-spores have the peculiarity of never leaving the mother cell. They swim around in the cavity bounded by the cell wall and shortly come to rest, arranging themselves to form a new net entirely within the parent cell. Thus by their habits one may readily distinguish the asexual zoospores and gametes of Hydrodictyon.

Now let us summarize the factors that will make Hydrodictyon form asexual zoospores at one time and gametes at another. The water-net grows luxuriantly in a culture solution containing a number of inorganic salts. If plants are removed from such a culture solution and placed in fresh water they will develop zoospores in 24 hours. The process takes place most rapidly if the temperature is slightly above the normal; indeed merely warming the water in which plants are living will frequently induce the production of zoospores. Plants refuse to form zoospores at a temperature as low as 8° C. but if such a culture be raised to the warmth of 16° or 20° the process is immediately resumed. Gametes are produced under very different conditions from those stated above. They demand organic food. Cultures of Hydrodictyon in a solution of cane sugar will almost certainly yield gametes after several days.

It frequently happens that the nets of Hydrodictyon will exhibit a well-defined tendency or preference to form either gametes or zoospores. Such a habit may be quite thoroughly broken by cultivating a plant under proper surroundings. Gamete-forming nets will shortly

produce zoospores if grown in solution of inorganic salts and in bright sunlight. Nets with strong inclinations to form zoospores can be made to produce gametes by cultivating in a sugar solution in subdued light or darkness. Plants that have no special inclination to form either zoospores or gametes may be decided one way or the other by the illumination, bright light producing zoospores and darkness gametes. It is also fair to say that sometimes the tendency to form zoospores is so strong that a plant will not yield for several generations to the conditions that generally bring about the immediate production of gametes.

Let these studies on Hydrodictyon and Ulothrix stand as illustrations of the kind of evidence presented in varying degrees by many algae and fungi and constantly increasing as investigations in physiology proceed. The general trend seems unmistakable. We may feel sure that sexual elements, gametes, have arisen from asexual reproductive cells with an immediate relation to and probably because of certain environmental factors. In a general way these factors are known to be light, temperature, osmotic pressure and, most important of all, the chemical nature of the environment with especial reference to the kinds of foods.

What was the change that came over the asexual reproductive cell when it took on the stamp of sex? The differences are best measured in the possibilities of the two elements. The asexual zoospores may quickly and readily produce a new individual. The gamete, generally speaking, must fuse with its kind or else die. We have seen that primitive gametes may germinate without conjugation but the resulting plants in the cases best known are weaker than normal individuals. We also know that the lower stretches of the plant kingdom furnish abundant illustrations of parthenogenesis, that is, the power of an egg cell to develop without fertilization. These exceptions, however, strengthen the evidence that the essential differences between gametes and asexual zoospores are qualities lacking in the former, and especially the ability to continue and sustain the mechanism demanded by vital processes.

With conjugation all is changed, and the sexually formed spore has the qualities lacking in the two gametes from which it arose. The protoplasm is in a sense rejuvenated and with the stimulus comes sooner or later an expression frequently more vigorous than that of the asexual spore.

The most striking conjecture on the significance and origin of sex has been presented under the name 'autophagy.' It is a very simple hypothesis. However, its simplicity is its greatest danger and will probably be its complete undoing, for enough is known to indicate that the factors and conditions that produce the sexual act are im-

mensely varied and complex. Autophagy explains the sexual act as a process by which sexual cells mutually devour one another. Each is fed to the other and by mutually contributing their substance both make possible the energy exhibited by the fusion cell.

Autophagy conceives the sexual cell (gamete) as one that lacks the energy of its progenitor, the asexual element. It is a cell reduced and starved. Ordinarily its vitality is at such a low ebb that further development is impossible. Sometimes it is not so far gone but that a favorable environment will induce parthenogenetic growth. The sexual cell may be brought back to virile activity with power to propagate the race, if supplied with the necessary energy. And the simplest method of attaining this end, according to autophagy, is the cooperative union of these weakened elements, a mutual feast, which revives the worn-out protoplasm and enables the fusion products to make a fresh start.

The hypothesis of autophagy may be attacked from several points, and becomes very unsatisfactory when so examined. It is crude and entirely insufficient to cover the subtle phenomena that it attempts to handle. The cause of the fusion of gametes involves problems of chemistry and physics which can only be investigated by methods of extreme delicacy and precision. One may see at a glance that conjugation is not the same as the actual feeding of one unicellular organism upon another. In such a case, which might be illustrated with many Protozoa, the captive form is destroyed and its dead substance is then worked over through elaborate changes into the protoplasm of the living cell. In the conjugation of sexual cells, the two masses of protoplasm fuse and mingle and perhaps the most significant feature of the process is the union of the two sexual nuclei.

As a matter of fact, sexual cells are, generally speaking, well nourished, and in all higher organisms the egg is specially provided with food, far above the amount ordinarily present in cells. The unfertilized egg does not lack food, but is unable to command the necessary energy or, if such be present, it is tied up in some form that cannot be used. The importance of the latter condition is indicated by the investigations of Dr. Loeb, who found that a slight increase in the density of sea-water will induce the immediate development of the unfertilized eggs of sea urchins, star fishes and a certain worm. In the earlier experiments, salts of magnesium and potassium were added to the sea-water, but later studies have shown that sugar induces similar parthenogenetic development. It is suggested that merely the withdrawal of water from the egg by osmosis is sufficient to cause its development without sexual intervention. And it may be supposed that normally the sperm brings to the egg substances that excite such conditions within the egg that water is given off. But we are far from

understanding how such results are accomplished in nature or what other factors may be concerned.

It is certainly plain that the conditions surrounding sexual processes are immensely complex, and as yet we only know them in part and for a very few organisms. There is every reason to expect that investigation will so add to these that the subject will consist of very complicated problems in physics and chemistry. But it is something to know that important factors exist outside of the organism controlling in great part the sexual phase, and that some of them are so simple as light, temperature and osmotic pressure. Much is gained for biology in the understanding that sexual elements have arisen from asexual reproductive cells under the stress of environmental influences; that sexuality is not inherent in life although presented in almost all higher organisms, and that, however complicated the extreme conditions may be, they have arisen through a process of gradual evolution.

In another paper I shall hope to show the steps by which the highly differentiated egg and sperm in various groups of plants developed from the similar gametes presented at the dawning of sex. As stated in the beginning of this paper, the topic is a chapter in itself and well deserves separate treatment.

THE FISHES OF JAPAN.

WITH OBSERVATIONS ON THE DISTRIBUTION OF FISHES.

By DAVID STARR JORDAN,

PRESIDENT OF LELAND STANFORD JUNIOR UNIVERSITY.

THE islands of Japan are remarkable for their richness of animal life. The variety in climatic and other conditions, the nearness to the great continent of Asia and to the chief center of marine life—the East Indian Islands—its relation to the warm Black Current or Kuro Shiwo—the Gulf Stream of the Orient—and to the cold current from Bering Sea, all tend to give variety to the fauna of its seas. Especially numerous and varied are the fishes of Japan.

About nine hundred species of fishes are known, from the four great main islands of Japan, and about two hundred more from the volcanic islands (Kuriles and Liu Kiu) to the north and south. Of the eleven hundred, about fifty are fresh water. All these are derived from the mainland of Asia. Two faunal districts, the north and the south, may be recognized among the fresh-water fishes. The mountain region and the region lying to the north of Fuji abound in trout, with salmon, sturgeon, lamprey and other northern fishes. In the southern district these are absent and the chief fresh-water fishes are ayu, or dwarf salmon, chubs, minnows, cat-fishes and loaches.

The marine fishes are far more varied, their distribution being mainly controlled by temperature and currents. Among these, five districts may be recognized, their range sufficiently indicated by the names, Kurile, Hokkaido, Nippon, Kiusiu, Kuro Shiwo and Liu Kiu. Of these, the Kurile Fauna is subarctic, similar to that of the Aleutian Islands, that of the Liu Kiu islands is tropical, that of the promontories, which strike out into the Kuro Shiwo, is Polynesian. The central region (Nippon) contains the forms essentially Japanese. Kiusiu has much in common with China, and Hokkaido with Siberia and Manchuria. Each of these districts overlaps, by a broad fringe, on the others.

It has been noted that the fish fauna of Japan bears a striking resemblance to that of the Mediterranean, and Dr. Günther has suggested that this can be accounted for by supposing that in recent times a continuous coast line and sea-passage extended from one region to the other, the Isthmus of Suez not existing.

The resemblance consists in the presence in the two regions of certain striking-looking fishes not found in other parts of the world. An analysis of these resemblances takes away much of their impressiveness. Most of the forms in question are widely distributed, ranging from Japan through India to the Cape of Good Hope. Only three genera are restricted to Japan and the Mediterranean. Resemblances equally strong exist between Japan and the West Indies, or between Japan and Australia. The differences are equally marked. The types regarded as of Japanese origin are all wanting in the Mediterranean. Those of Mediterranean origin are wanting in Japan. There are two main reasons why one fish fauna may resemble another; the one, actual connection, so that fishes migrate from one region to another; the other, similarity of physical conditions, favoring in each region the development of similar kinds of fishes. The evidence points toward the theory that similarity of physical conditions is the chief source of resemblance between Japan and the Mediterranean. The resemblance between Japan and the West Indies is due to this cause, while that of Japan to the East Indies is due largely to direct connection. If Japan and the Mediterranean were ever connected, the Red Sea must have been a region of junction. Yet, while the Red Sea in its fishes closely resembles southern Japan, it has almost nothing in common with the Mediterranean. Except a few shallow water or brackish water types, the shore fishes of the two regions are wholly distinct, none of the characteristic genera of either sea being found in the other.

Yet, geologists affirm that in Pliocene or Post-Pliocene times the Isthmus of Suez was submerged. It is made up of Pliocene deposits with alluvium from the Nile and drifting sand-hills. Admitting this to be true, the nature of the fishes shows that this channel must have been very shallow and probably in part occupied by fresh water. No bottom-fish or rock-fish has crossed it—only sting-rays, torpedoes, eels and mullets appear to have passed from one side to the other. It must have been impossible for Japan and the Mediterranean ever to have exchanged their deep-water fishes in this way. The only other alternative is the Cape of Good Hope, and this barrier is, to this day, passed by many characteristic fishes of both oceans.

Four hundred and eighty-three genera of fishes are known from Japan. For the purpose of our present study we must take from this list all the fresh-water types, derived from China; all the northern types, derived from Bering Sea and the general Arctic stock; all the pelagic fishes, at home in the open sea, and all the bassalian fishes, or those inhabiting great depths below the range of climatic changes. After these are withdrawn, we have left the shore fishes of tropical, or semi-tropical, origin. Of these, Japan has 334 genera; the Mediterranean, 144; the Red Sea, 191; India, 280; Australia, 344; New

Zealand, 108; Hawaii, 144; West Indies, 299, and the Panama region, 256.

Common to Japan and the Mediterranean are 79, all but two being of wide distribution; to Japan and the Red Sea, 111; to Japan and Hawaii, 82; to Japan and Australia, 135; to Japan and the West Indies, 113; to Japan and Panama, 91. To the Mediterranean and the Red Sea, 40 genera are common, all of wide distribution; to the West Indies and the Mediterranean, 70, 59 being of wide distribution; to the West Indies and Panama, 179, only 101 being of wide distribution.

It is evident from an analytical table that the warm-water fauna of Japan, like that of Hawaii, is derived from that of the East Indies and Hindostan; that the fauna of the Red Sea is derived from the same source; that the Mediterranean fauna bears no special resemblance to that of Japan rather than to that of the other parts of Eastern Asia with like conditions of temperature and no greater than is borne by the West Indies; that the fauna of the two sides of the Isthmus of Suez have relatively little in common, while those of the two sides of the Isthmus of Panama show a remarkable degree of identity.

When the fishes of Panama were first described, it was claimed that their species were almost entirely identical with those of the West Indies; this statement was followed by speculations on the relation of the depression of this Isthmus to the Gulf Stream, and to the glacial epoch. Further investigations by Jordan, and by Evermann and Jenkins showed the fallacy of this claim of identity. Of about 1,400 species now known from the two sides of the Isthmus, only 70 are identical, or five per cent. of the whole, and about 10 of these are almost cosmopolitan in the tropics. Dr. Paul Fischer finds about three per cent. of the mollusks identical on the two coasts.

Dr. R. T. Hill goes on to show that there is neither geological nor biological evidence of the submergence of the Isthmus of Panama since Tertiary times, and that such a barrier existed as far back as Jurassic times. There is, however, evidence of a brief connection in Tertiary time at the end of the Eocene period.

Assuming this to be true, the actual facts of distribution seem to be in accord with it. The period of depression was before the life-time of most of the present species. It was, however, not earlier than the period of most of the present genera. It was relatively shallow, but wide enough to permit the infiltration from the Caribbean Sea to the Pacific of species representing most of the genera of sandy bays, rocky tide pools and brackish estuaries. Since the channel was closed, the species left on either side have undergone modification in varying degrees, mostly retaining generic identity, while losing some of their specific characters.

Doubtless, local oscillations in coast lines have taken place and are even in operation at present, but the time has passed when a dance of continents can be invoked to explain anomalies in animal distribution. Most of these will be found to have simple causes, when we know enough of the facts in the case to justify a hypothesis.

The laws governing animal distribution are reducible to three very simple propositions:

Every species of animal is found in every part of the earth having conditions fit for its existence, unless

(*a*) Its individuals have been unable to reach the region in question through barriers of some sort, or,

(*b*) Having reached the region, the species is unable to maintain itself through lack of capacity for adaptation, through severity of competition with other forms, or through destructive conditions of environment, or else.

(*c*) Having entered and maintained itself, it has become so altered in the process of adaptation as to become a species distinct from the parent type.

In general, the different types of fishes are most specialized along equatorial shores. The processes of change through natural selection take place most rapidly there and produce more far-reaching modifications. The coral reefs of the tropics are the centers of fish-life, corresponding in fish economy to the cities in human affairs. The fresh water, the Arctic waters, the deep sea and the open sea represent ichthyic backwoods—regions where change goes on more slowly and in which archaic types survive.

The study in detail of the distribution of the fishes of the tropics, is most instructive. The study of the origin of the fish groups of Japan affords a fascinating introduction to its multifarious problems.

THE OMEN ANIMALS OF SARAWAK.

By A. C. HADDON, F.R.S.,
CAMBRIDGE UNIVERSITY.

THE cult of the omen animals is of such importance in the daily life of most of the tribes of Borneo that it is desirable that more attention should be paid to it by those who have the opportunity of studying it at first hand.

The Venerable Archdeacon J. Perham has given a full account of the Iban or Sea Dayak religion in the 'Journal of the Straits Branch of the Royal Asiatic Society' (Nos. 1, 2, 3, 4, 5 and 8), which has been reprinted by Ling Roth in his book, 'The Natives of Sarawak and British North Borneo.' Mr. Ling Roth has also compiled some other scattered references on omens (Vol. I., pp. 221–231). Although the following notes are very imperfect, they contain some new facts derived from Dr. C. Hose, and also, thanks to information derived from Dr. Hose, I am able for the first time to give a fairly complete list of the omen animals of Sarawak, with their scientific names. I have taken the liberty of abstracting the following account of the way in which birds are 'used,' as the Ibans say, from Archdeacon Perham's most valuable papers, as it is the best description known to me of what is of daily occurrence in Borneo:

The yearly rice farming is a matter of much ceremony as well as of labor with the Dayaks, and must be inaugurated with proper omens. Some man who is successful with his padi will be the augur and undertake to obtain omens for a certain area of land, which others besides himself will farm. Some time before the Pleiades are sufficiently high above the horizon to warrant the clearing the grounds of jungle or grass, the man sets about his work. He will have to hear the *nendak* (Cittocincla suavis) on the left, the *katupong* (Sasia abnormis) on the left, the *burong malam* (a locust) and the *beragai* (Harpactes duvauceli) on the left, and in the order I have written them. As soon as he has heard the *nendak*, he will break off a twig of anything growing near and take it home and put it in a safe place. But it may happen that some other omen bird, or creature, is the first to make itself heard or seen, and in that case the day's proceeding is vitiated; he must give the matter up, return and try his chance another day; and thus sometimes three or four days are gone before he has obtained his first omen. When he has heard the *nendak*, he will then go to listen for the *katupong* and the rest, but with the same liability to delays; and it may possibly require a month to obtain all those augural predictions, which are to give them confidence in the result of their labors. The augur has now the same number of twigs and sticks as birds he has heard, and he takes these to the land selected for farming and puts them

in the ground, says a short form of address to the birds and Pulang Gana (the tutelary deity of the soil, and the spirit presiding over the whole work of rice farming), cuts a little pass or jungle with his parang and returns. The magic virtue of the birds has been conveyed to the land.

For house-building the same birds are to be obtained and in the same way. But for a war expedition, birds on the right hand are required, except the *nendak*, which, if it make a certain peculiar call, can be admitted on the left.

These birds can be bad omens as well as good. If heard on the wrong side, if in the wrong order, if the note or call be of the wrong kind, the matter in hand must be postponed, or abandoned altogether; unless a conjunction of subsequent good omens occur, which, in the judgment of old experts, can overbear the preceding bad ones. Hence, in practice, this birding becomes a most involved matter, because the birds will not allow themselves to be heard in straightforward orthodox succession. After all, it is only a balance of probabilities; for it is seldom that Dayak patience is equal to waiting till the omens occur, according to the standard theory.

These are the inaugurating omens sought in order to strike a line of good luck, to render the commencement of an undertaking auspicious. The continuance of good fortune must be carried on by omen influence to the end.

When any of these omens, either of bird, beast or insect, are heard, or seen by the Dayak on his way to the padi lands, he supposes they foretell either good or ill to himself or to the farm; and in some cases he will turn back and wait for the following day before proceeding again. The *nendak* is generally good, so is the *katupong*, on the right or left, but the *papau* (Harpactes diardi) is of evil omen, and the man must beat a retreat. A *beragai* heard once or twice matters not; but if often, a day's rest is necessary. The *mbuas* (Carcineutes melanops) on the right is wrong, and sometimes it portends so much blight and destruction that the victim must rest five days. The 'shout' of the *kutok* (Lepocestes porphyomelas) is evil, and that of the *katupong* so bad that it requires three days' absence from the farm to allow the evil to pass away; and even then a *beragai* must be heard before commencing work. The *beragai* is a doctor among birds. If the cry of a deer, a *pelandok* (Tragulus), be heard, or if a rat crosses the path before you on your way to the farm, a day's rest is necessary; or you will cut yourself, get ill or suffer by failure of the crops. When a good omen is heard, one which is supposed to foretell a plentiful harvest, you must go on the farm and do some trifling work by way of 'leasing the work of your hands' there, and then return; in this way you clench the foreshadowed luck, and at the same time reverence the spirit which promises it. And should a deer, or *pelandok* come out of the jungle and on to the farm when you are working there, it means that customers will come to buy the corn and that therefore there will be corn for them to buy. This is the best omen they can have, and they honor it by resting from work for three days.

But the worst of all omens is a dead beast of any kind, especially those included in the omen list, found anywhere on the farm. It infuses a deadly poison into the whole crop and will kill some one or other of the owner's family within a year. When this terrible thing happens they test the omen by killing a pig and divining from the appearance of the liver immediately after death. If the prediction of the omen be strengthened, all the rice grown on that ground must be sold; and, if necessary, other rice bought for their own consumption. Other people may eat it, for the omen only affects those at

whom it is directly pointed. A swarm of bees lighting on the farm is an equally dreadful matter.

The 'barking' deer *(Cervulus muntjac)* is very important as an omen to all peoples, but least so to the Ibans. The bark of this deer prevents people from continuing their journey, and even divorces people who are newly married.

The little chevrotains, 'planok' or 'plandok' *(Tragulus napu* and *T. javanicus)*, have the same function as the muntjac, so far as a journey is concerned, but otherwise they are not very important.

The Rev. W. Chalmers says: "If the cries of any of the three kinds of deer found in Sarawak be heard when starting on a journey, or when going to consult the birds by day or by night, it is a sign that if the matter in hand be followed up sickness will be the result. Also, if a newly married couple hear them at night, they must be divorced, as, if this be not done, the death of the bride or bridegroom will ensue. I myself have known instances of this omen causing a divorce, and I must say the separation has always been borne most philosophically by the parties most concerned; in fact, the morning of one of these divorces I remember seeing an ex-bridegroom working hard at shaping some ornamental brass-work, which Dayak women are in the habit of wearing round their waists, and he said that he intended to bestow it on a certain damsel whom he had in his eye for a *new* wife."

Sir Spencer St. John writes: "To hear the cry of a deer is at all times unlucky, and to prevent the sound reaching their ears during a marriage procession, gong and drums are loudly beaten. On the way to their farms, should the unlucky omen be heard, they will return home and do no more work for a day."

A Malay told me: If a Sarawak Malay was striking a light in the evening in his house and a plandok made a noise at the same time, the whole family would have to leave the house for three days. Should they not do so, the house would catch fire and be burned down or sickness or other calamity would overtake them.

On the second day of one of Dr. Hose's journeys through the jungle, the chief who was with him saw a plandok rush across the path. Hose being behind, did not observe it, but he saw all his party sitting on a log, and the chief informed Hose that he could not proceed that day, as his 'legs were tied up.' This was most inconvenient, as Hose was in a hurry, but the men would not go on. Hose freely took upon himself all the responsibility and said he would go first and would explain to the plandok that he was the person in fault. The chief would not agree even to this, and did not budge, but said he would follow the next day. Hose went on with some of the men as far as he could get and camped. Next day the chief caught Hose up at noon and appeared very much

surprised that no harm had befallen him. Hose chaffed him about his legs and was 'pleased to see that they had become untied!'

The small viverrine carnivore *(Arctogale leucotis)* is one of the most important omens for Kenyahs and Kayans, who, however, have a particular dread of coming into contact with it. Lest it should produce sickness, they will never even touch a piece of its dried skin. It is not an omen for the Ibans, nor for the Punans, who even kill and eat it. After having obtained other omens, the Kayans are glad to see the munin, as it is useful in conjunction with other omens, but they do not like to hear it squealing.

The screeching of the large hawk *(Haliastur intermedius)*, which is closely allied to or a sub-species of the Brahminy kite *(H. indus)*, is a cautionary sign with the Kayans, and though it is not in itself a bad sign, they will generally return home from any enterprise on hearing it, if they were still taking omens, or, at all events, they will remain where they are for a day. What the Kayans and Kenyahs most desire when 'owning' a hawk is to see it skim silently, without moving its wings, either to the right or to the left. Any other action than this, such as a swoop down or continued flapping of the wings, is considered unfavorable. Something bad is going to take place; they do not know what it may be or to whom it will happen, and one who sees the hawk do this turns away his face or retires to some place out of the sight of the hawk, lest, on being observed, he should be the one on whom the misfortune will fall. On such an occasion no one speaks a word, and all return into the house and wait from ten minutes to half an hour. If they are very anxious to go on again that day, they slip quietly out of the house, so that the hawk may not see them, get into their boats and start on their journey.

If the hawk appears on the wrong side when men are paddling, a few days away from home and nearing another village, they immediately turn the boat right round, pull to the bank and light a fire. By turning round they put the hawk on the right side, and, being satisfied in their own minds, they proceed on their journey as before.

The hawk, or, as the Ibans call it, Sengalong Burong, is a very important being. The little woodpecker *(Sasia abnormis)*, 'Katupong' is his son-in-law, being married to Dara Inchin Temaga Indu Monkok Chilebok China, a poetical *hantu*, who mentions in her songs the names of all the mouths of the rivers in their order from Sarawak River to some distance up the coast. (This is probably the remnant of a migration saga.) The smallest of the trogons, *Harpactes duvauceli*, 'Beragi,' also married another daughter of Sengalong Burong.

Although this is the most important of any Iban omen bird, it is his sons-in-law that are most used. Food is offered to Sengalong Burong.

I believe that other large hawk-like birds are used as omens. The Brahminy Kite is popularly supposed in India to be the sacred Garuda, the mythical bird, half eagle and half man, which, in Hindu mythology, is the *Vahana,* or vehicle of Vishnu. Whenever Bengali children see one of these birds they cry out:

Let drinking vessels and cups be given to the Shankar Chil (Brahminy Kite),
But let the Common Kite get a kick on its face.

There is a kingfisher that lives in the jungle *(Carcineutes melanops)* which is not a particularly lucky bird. If, when they are making a trap, the Ibans hear the long, mournful whistle of the 'Membuas,' they know that, although the trap will catch things, it will only be after an interval of ten to fourteen days that they will have any luck. On other occasions it is not unusual for them to catch little partridges, such as *Rollulus rouloul,* directly they have set up the trap, but often, under ordinary circumstances, it will be a day before they catch anything.

The Kenyahs apparently dislike this bird, which they call 'asi,' as it is not very favorable; in fact, they would rather not see it.

The white-crested hornbill *(Berenicornis comatus),* which has a moderate-sized black-keeled casque on its beak and bare blue orbits and throat, is an omen that is sought for by Kenyahs and Kayans, particularly by the latter, when felling jungle for planting and when going on the war-path. The Kenyahs use it slightly, and the Ibans not at all; it is, in any case, an omen bird of secondary importance.

The trogon, called by the Ibans 'Papau' *(Harpactes diardi),* is particularly useful to these people when hunting in the jungle for deer, pigs, etc., as it is a sure sign that they will obtain something that day; the bird's note of 'Pau, pau, pau,' infuses fresh energy into them. Supposing some Ibans were making a spring-trap *(panjok),* the moment one of them heard the cry of the 'Paupau' or 'Beragai' *(H. duvauceli),* he would at once snap off or cut off a small twig with a parang; the small piece of wood then cut or broken off is used for the release of the trap; the man would at the same time remark to the bird, 'Here we are.'

Other tribes such as the Kenyahs and Punans use *Harpactes diardi* as an omen, but it is not an important one. *H. duvauceli,* on the contrary, is of very considerable importance to the Kenyahs when going on the war-path, it being one of the omens of which it is imperative to obtain a sight or hearing. *H. kasumba* is employed indifferently with *H. diardi.*

Lepocestes porphyromelas is one of the most important of the omen birds, as it makes two perfectly distinct notes, one of which is favorable and the other unfavorable. On a rainy day it calls 'tok, tok, tok,' but

when the sun comes out it bursts into long 'kieng, kieng'; 'tok' is bad, but 'kieng' is good.

When a Kenyah hears the 'tok' cry, he immediately stops, lights a fire and takes the usual precautions in talking to it. He knows perfectly well that the same bird makes the two notes, and he waits for the 'kieng.' His explanation is that when the bird calls 'tok' it is angry, and that it is in a good temper when it sings 'kieng,' and therefore it is well not to go contrariwise to the omen. The Ibans behave in a similar manner. The Kenyahs regard it as a bird of warning, but not one that assists in getting anything. If a man was doing anything with a parang, knife or other sharp-edged tool and heard even a 'kieng,' he would probably desist from further use of it for that day.

The little woodpecker *(Sasia abnormis)* is in high favor among the Ibans; in fact, they consider it most important, as he represents his father-in-law, 'Sengalong Burong.' The 'Katupong' appears to produce whatever result they require. It is of less importance with other peoples of Sarawak.

Mr. Crossland informs us if a katupong enters a house at one end and flies out the other, men and women snatch up a few necessaries, such as mats and rice, and stampede, leaving everything unsecured and the doors unfastened. If any one approaches the house at night, he will see large and shadowy demons chasing each other through it, and hear their unintelligible talk. After awhile the people return and erect the ladder they have overthrown, and the women sprinkle the house with water 'to cool it.'

A kind of thrush *(Cittocincla suavis)* is particularly useful to the Ibans when looking for gutta or other jungle produce. 'Nendak' is a good bird too for them to own, as it is a Burong chelap, and, on hearing it, they would not be afraid of any sickness.

Before starting on a gutta expedition, they would require to see something before 'beragai' *(Harpactes duvauceli),* as this is a 'burong tampak,' that is, an omen animal that is potent for hunting. What they like is: First, to get 'nendak,' then wait three days while they are owning it, finally to get 'beragai' on the right. This combination signifies certain success; not only would they find gutta, but would obtain plenty of it, and no harm or sickness would befall them. If, however, they went for gutta on 'beragai' alone, and that, perhaps, appeared on the left, they would obtain a fair amount of gutta, but they would stand a good chance of some misfortune happening to them, and one of their party might fall sick, or even die.

The Tailor bird *(Orthotomus cineraceus),* although employed by Ibans only, is of very little use, as it is only a secondary burong. It may be employed as an additional argument when deciding for 'Selam,' or trial by the water ordeal. This consists in the two dispu-

tants putting their heads under water, and the one who has the most staying power having right on his side.

The Bornean shrike *(Platylophus coronatus)*, which has an erectile crest of long and broad feathers on its head, is used by the Ibans as a weather prophet on account of its unerring faculty of foretelling a storm, for whenever its whistle is heard, rain is always to be expected. It is very important for Kenyahs and Kayans in connection with tilling farms. When Kayans are clearing any undergrowth for a farm, after having offered to 'Niho' *(Haliastur intermedius)* and other omen animals, it is desirable that they should hear 'pajan,' the shrike, for then they know they will get plenty of padi of good quality, but there will be a good deal of hard work, and possibly a considerable amount of sickness and cuts and wounds. If they procure this omen, they take the precaution of building very substantial granaries.

Three species of Sun birds *(Arachnothera longirostris, A. modesta* and *A. chrysogenys)* are very important to Kayans, Kenyahs and Punans. Any of these species is used impartially, and they bear the name of 'Sit' or 'Isit.'

The 'Sit' is always the first bird to look for when undertaking anything—fortunately, an individual of one of the three species is almost always to be seen crossing the river. It is one of the least important omen birds with the Ibans. When Kayans, Punas and Melanaus go in search of camphor, it is first necessary to see a 'Sit' fly from right to left, and then from left to right. A Melanau, who is intending to start on such an expedition, sits in the bow of his boat and chants:

"O Sit, Sit, ta-au, Kripan murip, Sit,
Ano senigo akau, ano napan akau.
Oh! Sit, Sit, on the right, give me long life, Sit,
Help me to obtain what I require, make me plenty of that for which I am looking."

An allied bird, *Anthreptes malaccensis*, is commonly mistaken by Kayans, but by them only, for *Arachnothera longirostris*. They use it as an omen bird, but it is not so used by the Kenyahs, by whom it is called 'Manok Obah.'

All the omen snakes are bad omens, and in the case of a Kayan seeing 'batang lima' *(Simotes octolineatus)*, he will endeavor to kill it and, if successful, no evil will follow; should he fail to kill it, then 'look out.'

I believe that the Ibans pay some regard to 'Sawa,' a large python *(Python reticulatus)* and to 'Tuchok,' a kind of Gecko *(Ptychozoon homalocephalum)*, and to 'Brinkian,' another kind of Gecko; but I do not know whether these are, strictly speaking, omen animals.

The omen padi-bug, 'turok parai' *(Chrysocoris eques)* is only of importance, and that to Kenyahs alone, because it injures the crops.

The bee 'Manyi' *(Melipona vidua)* is an Iban omen only. If a swarm of bees settled underneath a house that had recently been built, it would be considered a bad sign, and probably it would be necessary to destroy that particular section of the house or to leave the house altogether.

Many Land Dayaks, on the contrary, keep bees in their houses, and among most of the peoples of Borneo, including the Ibans, it is most lucky in planting time to dream of an abundance of bees.

There are other creatures whose appearance, cry or movements may signify good or bad luck which are not omen animals (*i. e.*, 'burong' or 'aman'), in the strict sense of the term. For example, the hawk owl *(Ninox scutulata)* makes a melancholy cry at night, on account of which it is very much disliked by the natives, who regard it as a foreteller of death. Its native name is 'Pongok.' If the Malay bear *(Heliarctos Malayanus)* climbs into an Iban's house, it is a bad sign, and the house would have to be pulled down.

According to Perham: "In answer to the questions of the origin of this system of 'birding,' some Dayaks have given the following: In early times the ancestors of the Malays and the ancestors of the Dayak had, on a certain occasion, to swim across a river. Both had books. The Malay tied his firmly in his turban, kept his head well out of water, and reached the opposite bank with his book intact and dry. The Dayak, less wise, fastened his to the end of his waist-cloth, and the current washed it away. But the fates intervened to supply the loss and gave the Dayak this system of omens as a substitute for the book."

Another story relates the following:

Some Dayaks in the Batang Lupar made a great feast and invited many guests. When everything was ready and arrivals expected, a tramp and hum, as of a great company of people, was heard close to the village. The hosts, thinking it to be the invited friends, went forth to meet them with meat and drink, but found, with some surprise, they were all utter strangers. However, without any questioning, they received them with due honor and gave them all the hospitalities of the occasion. When the time of departing came, they asked the strange visitors who they were and from whence, and received something like the following reply from the chief: I am *Sengalong Burong*, and these are my sons-in-law and other friends. When you hear the voices of the birds (giving their names), know that you hear us, for they are our deputies in this lower world.' Thereupon the Dayaks discovered they had been entertaining spirits unawares, and received as reward of their hospitality the knowledge of the omen system.

Archdeacon Perham is perfectly right in his statement that:

"The sacredness of the omen birds is thus explained: They are forms of animal life possessed with the spirit of certain invisible beings above, and bearing their names; so that when a Dayak hears a 'Beragai,' for instance, it is really the voice of 'Beragai,' the son-in-law of Sengalong Burong; nay, more,

the assenting nod or dissenting frown of the great spirit himself. . . . 'These birds,' says Sengalong Burong, 'possess my mind and spirit, and represent me in the lower world. When you hear them, remember it is I who speak for encouragement or for warning.' . . . The object of the bird-culters is like that of all other rites: to secure good crops, freedom from accidents and falls and disease, victory in war, profit in exchange and trade, skill in discourse and cleverness in all native craft."

We know that such very distinct peoples in Sarawak alone, as the Ibans (Sea Dayaks), Land Dayaks, Muruts, Punans, Kayans and Kenyahs, pay attention to omen animals and, in most cases, to the same animals. This points to a common origin of the cult, for in some cases there is no specially obvious reason why that particular species of animal should have been selected. In the three last mentioned peoples the names of the omen animals are practically similar, but many of the Iban names are different.

There can be little doubt that this cult is indigenous to Borneo; it is probable that a cult of omen animals formed part of the fundamental religious equipment of the Ibans before they migrated to Borneo, but it is also probable that the Ibans have borrowed somewhat from neighboring indigenous tribes. Much more information must be obtained before a satisfactory history of this cult can be written.

SCIENTIFIC LITERATURE.

THE METRIC SYSTEM.

To one of scientific tastes, who at the same time welcomes the recent American renaissance of the historical novel, or to one whose faith in the common sense of his countrymen may waiver on considering their apathy towards the metric system, a recent work by M. Bigourdan* will have great fascination. Nor are these words carelessly chosen, for a more fascinating work on any phase of the history of science has not appeared in recent years. It is true that the topic seems trite enough. All the world knows the story, or thinks it does; the French revolution, the general upheaval, the different systems proposed, Méchain's mistake in the longitude of Barcelona, the consequent error in the meter, the final adoption of the system by a large majority of the civilized countries, all this is familiar. But one has only to read a dozen pages of M. Bigourdan's work to find himself in the midst of a wealth of interesting history of which he probably never even heard.

The fact is, it needed some one connected with the Paris Observatory to write such a work, and even he could not have done it until of late. For although the observatory has long had in its possession the original documents deposited there by virtue of a decree of the year 12, it is only recently that it received the valuable manuscripts relating to the early history of the system, which were given by Mme. Laugier, who had received them from her father, M. Mathieu, who in turn had them from a no less important actor in the drama than M. Delambre himself.

It is impossible to give in a few words any worthy *résumé* of the work, or adequately to speak of its style. It opens with a chapter on the precursors of the reform, going back even to the system under Charlemagne, to the effects of feudalism and to the efforts of such early leaders as Mouton, Huyghens and Wren. This is followed by a statement of the action of the Assembly on Talleyrand's proposition, the history of the provisional meter, the work of the temporary commission, the efforts at nomenclature and so on through the establishing of the system on a scientific foundation. Then come the long story of its adoption by France, ending with the law of July 4, 1837; the longer story of its struggles for recognition in other countries, and the later history of the International Bureau and its remarkable metrological labors at St. Cloud,

Still less is it possible to give, in the limited space at command, any idea of the thrilling historic action so unassumingly stated in the documents at M. Bigourdan's command. The difficulties of men like Delambre and Méchain, unable to make surveys without being suspected of signaling to the enemy, arrested as spies because they wished to visit their triangulation stations, imprisoned, insulted, limited in the bare necessities of life, the only wonder is that other errors than that of Méchain did not find frequent place in the work. 'I am an academician,' said Delambre to a sansculotte who

* 'Le systéme métrique des poids et mesures. Son établishment et sa propagation graduelle, avec l' histoire des opérations qui ont servi a déterminer le métre et le kilogramme.' Paris, Gauthier-Villars, 1901; pp. vi+458; price 10 fr.

examined his passports. 'There isn't any *Cadémie*, no *Cadémie* at all,' blurts out the surly guard; 'all the world's equal. You come along with us!'

To the American scientist, educator or promoter of foreign trade, however, the chief interest in the work lies in the story it tells of the adoption of the system by most of the non-English-speaking countries of the world. The common objections of those who have given the subject little thought, objections to nomenclature, to the magnitude of the units, to the difficulty of educating the people, to the error in the meter, objections which have been so thoroughly considered in the century past and in so many countries, and which have proved of so little consequence—these are considered fully and judiciously. It will be unfortunate if some of the societies interested in the progress of the system do not arrange for translating the entire work, both for the enlightenment of those who have given the subject little attention and for the help of those who believe that America can no longer afford to stand out against a system which the great majority of civilized nations are using.

BOOKS ON NATURE STUDY.

'THE SEA-BEACH AT EBB-TIDE,' by Augusta Foote Arnold (The Century Co.), meets a well-defined need for popular accounts of the natural history of the seaside. It describes the animal and plant life found on the beach and rocks between tide marks and washed up after storms. There are chapters on the distribution of animals and plants, on methods of collecting and preservation, on classification and on various peculiarities of certain groups. Then follows an account of the marine algæ and marine invertebrates, systematically arranged with the formality of a manual. This portion of the book is abundantly illustrated with photographic reproductions. Some of these are very good, but many are not as clear as could be wished and do not compare favorably with the beautiful book work exhibited in some of the recent popular accounts of flowering plants. That the book is far from being strictly accurate becomes apparent to any one who critically examines the treatment of groups with which he is familiar. Nevertheless the conspicuous forms are in the main sufficiently described and, what is more important, so figured that the tyro will have little difficulty in identifying specimens at hand. There is sure to be much confusion, however, of the more minute types such as the hydroids with the delicate filamentous seaweeds that should be studied with the compound microscope.

The author's attitude towards classification seems strained. The account of every large group is prefaced by a table of the families, genera and species to be considered. These synopses remind one of the outlines found in dictionaries and are very far from the spirit of classification that now dominates natural history. Such arrangements have but small and passing value in the constantly shifting scenes of systematic zoology and botany. Emphasis laid upon classification throws into the background the wealth of interest in the life and habits of organisms which we term their natural history. But a more important criticism is the loose and inaccurate conception of the significance and use of nomenclature. When the author says that specific names are 'occasionally the names of botanists who first described the plants' (p. 29), she shows much ignorance of the methods of systematists. It seems that the spirit of the present-day natural history is rather against collecting, that the best thought is directed to the out-of-doors study of particular groups in some detail rather than to the recognition of a very large number of forms, to the study of their home life with camera and sketch book rather than to

their collection and preservation. And the most interesting popular books on natural history in recent years have exhibited a very intimate knowledge of the forms considered. There is a charm in familiar friendship that is far more satisfactory than casual acquaintance, and it is a matter of small importance what the forms are—whether birds or bees or some group of plants.

One can hardly ask for a better piece of book work than 'Flowers and Ferns in their Haunts' by Mabel Osgood Wright (Macmillan). The charm lies in the beautiful photographic reproductions. These exhibit the details of flowers or ferns in the foreground against rock and in other picturesque situations with a sharpness that is very remarkable and in most delicate contrast to the soft backgrounds. With this detail is a choice of subjects in their surroundings that shows great feeling for the appropriate and artistic. The text is a running account of walks and rides in woods and over hill and dale in varying seasons of the year. The descriptions, chiefly of flower societies, are quite free from technicalities. The point of view is always imaginative and human rather than scientific. The book can scarcely be said to be botanical, except that flowers form the subject of a pleasing account of nature in her varying moods always treated figuratively and with much personification. Two human characters beside the author are carried through the book, one a quaint and interesting old man, the other a conventionally educated young woman, whose presence except as a foil seems somewhat out of place in these pages.

THE PROGRESS OF SCIENCE.

FOREIGN ASSOCIATIONS FOR THE ADVANCEMENT OF SCIENCE.

THE national scientific associations of Great Britain, Germany and France held their annual meetings during the month of September. The British Association met at Glasgow, under the presidency of Professor A. W. Rücker, the eminent physicist. Professor Rücker, who has recently been elected president of the reorganized University of London, gave an excellent address on the present trend of opinion in regard to the atomic theory; and the addresses of the presidents of the sections were of the usual high order. The section of education, organized for the first time, attracted special attention; we are, therefore, fortunate in being able to publish in this issue of the MONTHLY the presidential address of Sir John Gorst. The attendance at Glasgow—1,912—was above the average, but not so large as at the previous Glasgow meetings of 1855 and 1876, the sesquicentennial of the University, the Engineering Congress and other events having anticipated local interest in scientific matters. The sum of £1,000 was appropriated for scientific grants. The meeting of the Association next year will be at Belfast under the presidency of Professor James Dewar, the well-known chemist.

The seventy-third meeting of German Men of Science and Physicians was held at Hamburg, with Dr. R. Hertwig, professor of zoology at Munich, as president. Professor J. H. Van't Hoff, the eminent chemist of Berlin, was president of the scientific sections and Professor B. Naunyn, professor of medicine at Strassburg, of the medical sections. There were in all twenty-seven sections for the medical sciences and eleven for the natural and exact sciences. The attendance was large—some 5,000 members—and the programs important. Special lectures were given by Dr. E. Lecher on 'Hertzian Waves,' by Professor T. Boveri on 'Fertilization' and by Professor W. Nernst on 'Electro-chemistry.'

The French Association met on the Island of Corsica under the presidency of M. Hamy, whose address reviewed the beginnings of anthropology in France. Owing doubtless to the centralization of scientific work at Paris, the migratory meetings of the French Association are less well attended than those of Germany and Great Britain, and the papers presented are less numerous and important. The Association, however, performs a useful work, and having a large endowment (some $270,000) is able to make liberal grants for scientific research.

PROFESSOR PAWLOW'S RESEARCHES ON NUTRITION.

THE award of the first Nobel prize to Professor J. P. Pawlow, the widely known physiologist of St. Petersburg, is a well-deserved testimonial to his valuable and extensive contributions to experimental science. During the last twelve years Professor Pawlow has been engaged more particularly in the study of certain aspects of nutrition, and in this work he has enlisted the services of a considerable number of co-workers in his laboratory at the Imperial Institute for Experimental Medicine in St. Petersburg. The researches which these years brought forth have led physiologists to revise in many particulars the current teaching in regard to digestion and secretion. Most of the results obtained by Pawlow and his pupils were originally published in the 'Archives des Sciences Biologiques de St. Petersbourg,' and in inaccessible Russian journals and

dissertations. The more important facts and conclusions were, however, collected and presented in organized form in a series of lectures delivered at the Institute for Experimental Medicine. These lectures, originally published in Russian, have been translated into German and issued in book form ('Die Arbeit der Verdauungsdrüsen,' Wiesbaden, 1898; J. F. Bergmann). They have been widely read and have received abundant praise everywhere.

The chief merit of Pawlow's work lies in the application of new experimental methods to the solution of important problems in the physiology of secretion and digestion. Thus the introduction of the combined œsophageal and gastric fistulas has led to original observations on the mechanism of secretion; while the possibility of obtaining pure gastric juice has given rise to renewed chemical investigation of the composition and properties of this secretion. By an ingenious method of isolating completely a portion of the stomach while keeping unimpaired the nerve distribution to the isolated part, still further advances have been made. Other methods have been applied by Pawlow to the study of the function of the pancreas and the production of the bile. The specific influence of the nervous system on secretion, and the paths along which this is exerted, have been ascertained more definitely than ever before. Pawlow's contributions to experimental technique in these departments of investigation are unique, and their influence is already shown in the renewed interest which they have aroused lately in the study of digestion in general. To the more purely chemical aspects, also, this brilliant investigator has directed his attention. A prominent German physiologist has remarked that so many noteworthy results have not been achieved by any single investigator (together with his pupils) since Beaumont and Blondlot, and, in more recent years, Heidenhain.

In addition to these researches, mention may be made of the splendid investigations on the seat of urea formation in the animal body, which were carried out conjointly with Professor Nencki. Here again it was the application of new experimental methods—the Eck fistula operation, by means of which direct communication is established between the portal vein and the vena cava in mammals—which inaugurated a fresh series of important contributions on the rôle of the liver in intermediary metabolism.

Aside from the clear analysis of the problems involved and the originality of the methods applied, accurate observation and unremitting energy characterize Professor Pawlow's work. Every result obtained is verified until it stands as a permanent fact. Physiologists will rejoice at the fitting recognition which such successful achievements have received.

ZINC IN DRIED FRUITS.

During the past few years the export of dried apples and other fruit from this country to the continent of Europe has been greatly interfered with by the presence of zinc; the discovery of traces of this metal in the fruit has been deemed sufficient ground for prohibiting its importation. The presence of the zinc has been accounted for by the zinc trays used in the fruit driers, but the abandonment of the metal for this purpose has not sufficed to free the fruit from suspicion. A service has been rendered American fruit growers by an investigation recently carried out by Herr Soltsien, of Görlitz. He was incited to this by the detection of quite a strong trace (0.0067 %) of zinc in some American 'evaporated apples,' which had evidently not been dried on zinc trays. He finds that when zinc is present in the soil or in the atmosphere, it is readily taken up by plants, and, by consumption of such contaminated vegetables and fruit, even into the human body.

This was confirmed by finding traces of zinc in a number of corpses. He enumerates many ways by which zinc was found to enter the soil, among which are the following: The drainage waters from many foundations contain considerable quantities of zinc. In all regions where zinc smelting is carried on, or where there are zinc or brass foundries, the vegetation contains zinc; this arises from the fact that the particles of zinc oxid are extremely light and are carried to great distances in the atmosphere. In one instance the effluent from a slaughter house was precipitated by an effective chemical for the purpose which was sold under the name of 'sulfate.' This precipitant was found to be a very impure zinc sulfate, containing much iron and manganese. The excess of the substance passed into the stream contaminating it with zinc, while the precipitate, consisting largely of zinc albuminate, went with the other slaughter house refuse as fertilizer. It is quite possible that much of the 'tankage,' so largely used in this country in the manufacture of fertilizers, contains no inconsiderable quantity of zinc. Where zinc is thus present in the fertilizer, it would be apt to pass in traces into the fruit raised on soil thus fertilized. It is reasonable to suppose that such minute quantities of zinc would be perfectly harmless when taken into the human system, but their detection would serve to throw unjust discredit upon American fruit growers, long after they have ceased to use zinc in any part of the evaporators with which the fruit can come in contact; at least when preparing dried fruit for the export trade, these precautions have for some time been taken.

AN ELECTROMAGNETIC BASIS FOR MECHANICS.

ABOUT forty years ago Maxwell pointed out the main features of the electromagnetic theory of light. This theory very soon supplanted the old mechanical wave theory, or the elastic solid theory; and now the fundamental notions in light are purely electric or electromagnetic in character. It is very remarkable, however, that aside from the change in the fundamental notions themselves the old theoretical structure remains to a very great extent unchanged and that even the old nomenclature lends itself easily to the needs of the new theory with few exceptions. The change that has followed upon Maxwell's work is very like the moving of a house from old to new foundations.

There is at the present time a prospect of a similar transfer of the entire subject of mechanics to a purely electromagnetic foundation. Every one realizes that the notions of inertia and of gravitation, and the principles involved in Newton's laws of motion are far too abstract in their nature, and as elemental notions they are far too complicated to be entirely satisfactory as a basis for the most concrete of the physical sciences. It seems that the theory of electromagnetism is to supply precisely what is needful to reduce mechanics to a more elemental basis. The change, if it come, will no doubt be similar to the change which has taken place in the theory of light; the superstructure of theoretical mechanics and even the nomenclature will remain to a great extent unaltered.

The possibility of explaining the inertia of matter electrically was first shown by Heaviside. A charged body has more momentum when moving at a given velocity than if it were not charged, and if the body is small enough in comparison with its charge *all* its momentum may be accounted for in this way.

The possibility of explaining gravitation was first pointed out by H. A. Lorentz, who attributes it to an excess of attractive over repulsive forces of electric charges.

A remarkable consequence of Heaviside's theory of inertia is that accelera-

tion is not strictly proportional to accelerating force and that kinetic energy is not strictly proportional to the square of the velocity of a moving body.

Up to the present time a very prominent feature of physical science has been the reduction of every kind of phenomenon to mechanics. The notional elements out of which nearly every theory is built up are essentially mechanical in their nature, if one may use the term mechanical in a broad sense to signify all kinds of geometrical, kinematical and dynamical relations. The reason for this preponderating rôle of mechanics is that, hitherto at least, only those theories are effectively useful which are built up out of sensuous elements, and nearly all our complicated sensations refer to space relations as perceived with the eye and to dynamic and space relations as perceived by the sense of touch and by the so-called muscular sense. It is not likely that the transfer of mechanics to an electromagnetic foundation will greatly affect the preponderating role of concrete mechanics in physical science.

TENDENCIES IN ZOOLOGY.

Zoology also has its fashions. The publication of the 'Origin of Species,' by establishing a new standpoint and new problems, led zoologists to an ever minuter study of comparative morphology, already made fashionable by the work of Cuvier, Johannes Müller and Owen. On the discovery of the chordate affinities of the Tunicates by Kowalewsky, in 1866, an impulse was given to the investigation of comparative embryology, in the hope of further information, which, viewed in the light of the biogenetic law, might add other links to the phylogenetic chain. And later, when the science of cytology came into definite existence, the embryologist, who at first was content to carry his studies back only so far as the gastrula, was incited to delve more deeply, and for a time cell-lineage became the fashion, while, following quickly in the footsteps of this, experimental morphology became a vogue. Not that this last was an entirely new department of investigation, but rather a revival under new conditions and points of view of the methods of study employed by Trembley and Spallanzani whose experimental researches on Hydra and the earthworm respectively have reached the dignity of classics.

The latest fashion, nature-study, as it is called, is likewise a revival of older methods. It is a rejuvenescence of the natural history of the ancients, a return to the methods of Gilbert White, methods which, while they have never failed to attract, have unfortunately been sadly neglected of late by the professional zoologist. The developments of his subject have been towards ever-increasing esoterism, until the stage has now been reached when the laity has lost touch with the professional and fails to appreciate the results which he elaborates in the privacy of his laboratory, surrounded by his complicated engines for cutting sections and his multitudinous reagent bottles. In so far as this new revival of natural history methods may serve to bring about again a *rapprochement* of the amateur and the professional, it is to be welcomed, and important additions to our knowledge of the habits and instincts of animals and the significance of these may be expected when men, specially trained in the methods of biological investigation and thought, turn their attention to these phenomena.

But the enthusiasm which usually accompanies investigation along a new line must not blind to the danger which lurks beneath. The hope which lies in the departure is that it will tend to place the study of instincts and habits on a scientific basis and yield scientific results founded on careful and accurate observations, that, in a word, it will bring order into the chaos of observa-

tions now on record. Of indiscriminate observation there has already been too much; what is needed is discrimination. There is danger that the camera may become as powerful a fetish as the microtome has been. To spend hours in most uncomfortable positions endeavoring to secure a nature picture is not necessarily self-sacrifice in the pursuit of science; it may result in the securing of a pretty picture but it may result in nothing more. Pretty photographs are of no more value than pretty microscope slides; both are valuable only for what may be learned from them, and it is the exercise of a discrimination between what may be merely pretty and what may be instructive that gives an observation scientific value. It is not more amateur photographers that are wanted but more historians of nature.

SCIENTIFIC ITEMS.

WE regret to learn of the death at the age of sixty-six years of Edward W. Claypole, professor of geology at Throop Institute, Pasadena, Cal., and of the death of A. F. W. Schimper, professor of botany at Bâsle, who died on September 9, at the age of forty-five years.

THE eightieth birthday of Professor Rudolf Virchow, which occurred on October 13, has been celebrated in Berlin with elaborate ceremonies. There was a reception in the Pathological Institute in the afternoon and a banquet in the dining hall of the Prussian Diet in the evening, followed by an official reception in the parliament hall. Professor Waldeyer, secretary of the Berlin Academy of Sciences, presented 50,000 Marks, subscribed by medical men in Germany toward increasing the Virchow research fund. The event was also celebrated in New York and other cities. The municipality of Berlin has resolved to call its new hospital, containing beds for 1,700 patients, the Virchowkrankenhaus.

A STATUE of Pasteur was unveiled on September 9, at Arbois, where he spent his childhood and his holidays in later life. The monument, erected at a cost of over $10,000, was designed by M. Daillon and represents Pasteur seated. On the pedestal are two bas-reliefs, one representing inoculation against rabies and the other agriculture profiting from Pasteur's discoveries. On the occasion of the unveiling addresses were made by M. Decrais, French minister of the colonies, and M. Liard, representing the Department of Public Instruction.

PRESIDENT SETH LOW presented his resignation to the trustees of Columbia University on October 7. It was accepted with expressions of deep regret, and Dr. Nicholas Murray Butler, professor of philosophy and education, was made acting president.

SURGEON-GENERAL GEORGE M. STERNBERG has returned to Washington after a tour of inspection in the Philippines. —Mr. John A. Fleming, of the U. S. Coast and Geodetic Survey, has arrived in Honolulu for the purpose of erecting and conducting a station for the study of terrestrial magnetism.

MR. J. E. SPURR, of the U. S. Geological Survey, who has been employed for geological surveys by the Sultan of Turkey, has begun work in Macedonia and Albania.

THE Fifth International Congress of Physiology was opened on September 17 in the physiological laboratory of the University of Turin, under the presidency of Professor Angelo Mosso. Sir Michael Foster was elected honorary president. More than 200 physiologists were present, and 186 communications were announced.—The Congress of the International Association for Testing Materials was held at Budapest, from September 9 to 14, under the presidency of Professor L. von Tetmajer, and was largely attended by engineers from all parts of the world.